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Architectural Science Review
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tasr20

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Published online: 24 Apr 2015.

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To cite this article: Şule Taşlı Pektaş (2015) The virtual design studio on the cloud: a blended and distributed approach for technology-mediated design education, Architectural Science Review, 58:3, 255-265, DOI: 10.1080/00038628.2015.1034085

To link to this article: http://dx.doi.org/10.1080/00038628.2015.1034085

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Architectural Science Review, 2015
Vol. 58, No. 3, 255–265, http://dx.doi.org/10.1080/00038628.2015.1034085

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The virtual design studio on the cloud: a blended and distributed approach for technology-mediated design education

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(*Received 30 September 2014; accepted 22 March 2015*)

The studio is widely accepted as the core in design education because it aims to integrate many curricular topics within its scope. However, learning environments in studio teaching have not been explored and exploited as a response to developing technology and changing socio-cultural context, yet. In order to alleviate the problem, this paper presents an innovative model for a virtual design studio which utilizes social networking media and cloud computing. The virtual design studio is conceptualized as a socio-technical system where intelligence is distributed across people and tools. The study proposes several means of augmenting intelligence in such a studio. The application of the theoretical framework is demonstrated in a real-life case study. The results of an empirical survey show that the proposed model was well accepted by the students. In the paper, the opportunities and challenges of this approach are discussed and suggestions are made for further studies.

Keywords: design studio; blended learning; flipped classroom; cloud computing; social networking media

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Introduction

The studio is the traditional mode of learning in design education. It is essentially a shared environment where students are assigned problems to solve and projects to complete through a process that is often acknowledged as a "reflective practice" or "a dialogue of thinking and doing through which [students] become more skilled" (Schön 1983). The teaching system of France's Ecole des Beaux Arts is often recognized as a foundation of current design studios (Lackney 1999). In the Beaux Arts model, students are given a design problem and guided by their instructors via critiques throughout the process. Typically, the process for each project culminates with an evaluation in the form of a final jury. The term "studio" also refers to the traditional space of design education. It is a physical space for a shared, prolonged, and communal activity that enables social interaction and experiential learning.

A virtual design studio can be defined generally as a type of studio that investigates possibilities offered by digital media and virtual environments to expand studio space beyond physical and time limits. Virtual design studios emerged in the early 1990s, almost parallel with the advent of the Internet. A computer-supported collaborative work discourse has been built gradually, and such studios have long been discussed as a way of promoting global teams, developing cultural interaction, and teaching collaborative design. Technology developments have often motivated new experiments in virtual design studios, from early text-based bulletin boards (Maher, Skow, and Cicognani 1999) to 3D virtual worlds (Nakapan and Gu 2011). Despite the hype created in the 1990s, the number of studies on virtual design studios has decreased in the last decade. The last decade has witnessed the emergence of new uses of the Internet and extensive use of mobile computing and multimedia. We now have a generation of students who have grown up with Internet technology and who are used to continuously receiving information in various formats and maintaining social relationships through distributed channels. Moreover, the increased number of students enrolled in design programmes has imposed pressure on traditional studio teaching (Bosman, Dredge, and Dedekorkut 2010).

Design education was unprepared for such changes, and has not yet developed a networked practice despite more than two decades of research in this area. There is thus a need for new educational theories, methods, and applications in design education. This paper revisits the concept of a virtual design studio and explores how it can evolve in response to developing technology and the changing socio-cultural context of design education. The paper presents a blended and distributed approach as a solution, and discusses the outcomes of that approach within the framework of a real-life case study.

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A brief review on virtual design studios

The roots of the Internet date back to the 1960s, but its public use flourished in the early 1990s (Kleinrock 2008). Internet applications have expanded continuously and quickly. This trajectory is also mirrored in virtual design studios. Wojtowicz (1995) edited an influential book titled "Virtual Design Studio" which documented the experience gained in a virtual design studio with participants from Barcelona, MIT, Harvard, Cornell, Washington University, St. Louis, The University of British Columbia, and the University of Hong Kong in one design exercise. The term "Virtual Design Studio" was coined in early 1993 within the framework of this experiment, as reported by Wojtowicz (1995). Early virtual design studios utilized multi-user dungeons and multi-user dungeons object-oriented (Maher, Skow, and Cicognani 1999), as well as specially designed software that combined synchronous and asynchronous approaches (Kolarevic et al. 2000). Later, 3D virtual worlds such as Active Worlds (Maher and Simoff 1999; Rosenman et al. 2007), SecondLife (Gu et al. 2009), and immersive virtual environments (Schnabel and Kvan 2001) were used in virtual design studios.

Transforming technology: Web 2.0 and cloud computing

The Internet has now evolved into a social and participatory environment that is often called Web 2.0, a term referring to web applications that enable information sharing, user-centred content generation, and desktop-free computing. The term "Web 2.0" is attributed to Tim O'Reilly, who defined the "Web as platform" concept, where software applications are developed for the Web rather than for the desktop. Typically, a Web 2.0 site facilitates interaction and encourages content creation rather than merely passive viewing of pre-published content. Examples of such sites include social networking sites, blogs, wikis, hosted services, web applications, and media-sharing sites. O'Reilly notes that the activities of users generating content could be "harnessed" to create value (2007). Social networking platforms, which deal with building and maintaining social relations among people, have attracted particular interest among many Web 2.0 applications. Such a platform includes a representation of each user (a profile), his/her links, and several other services such as e-mail, instant messaging, and tagging. Social networking sites such as Facebook, Google+, and Twitter have become increasingly popular in the last decade, and academia has already begun to discuss how they can be utilized in education (Roblyer et al. 2010).

Another parallel development in the Web 2.0 era is cloud computing, which can be defined as delivering computing as a service whereby shared resources and information are provided over the Internet. Some scholars have argued that cloud computing is a form of Web 2.0 because both denote computing on the Internet (Ryan 2005). Wang et al. (2010) defined three operational mechanisms for cloud computing: hardware as a service, software as a service, and data as a service. A cloud computing platform enables its users to manipulate remote data with minimal desktop hardware and software requirements. These new uses of the Internet are creating new models for professional practice, collaboration, and computing. Therefore, their utilization in education deserves attention.

Web 2.0-based virtual design studios are still emerging. Shao, Daley, and Vaughan (2007) were the first to suggest that Web 2.0 technology could be used in virtual design studios. Ham and Schnabel (2011) described a Web 2.0-based virtual design studio that utilized a social networking site. Pak and Verbeke (2012) conducted a Web 2.0-based graduate urban design studio and concluded that the use of Web 2.0 technology augmented reflective learning processes. Whiting and Varadarajan (2009) presented an early experiment with cloud computing in a design education setting. Schaefer et al. (2012) described a graduate level cloud-based engineering design course that utilized a learning management system (LMS) and several other applications chosen by the students such as Google Docs, Google Groups, and Skype. It should be noted that all these studies are merely descriptive/narrative in nature. There is a need for robust theoretical frameworks and systematic analyses to provide better insight into such studios. Kvan (2001) pointed that discussions about virtual design studios typically focused on technological issues while the experiences of the users were neglected. After 15 years, this argument still deserves attention. Within this perspective, the particular questions explored in the present study are listed below:

(1) What is the current socio-cultural context of design education and how can new generation virtual design studios respond to this context?
(2) How can a theoretical framework be proposed to conceptualize contemporary virtual design studios?
(3) What are students' opinions about such a virtual design studio?

The current socio-cultural context of design education

Technological developments have a bilateral relationship with the general socio-cultural context. To understand either of these concepts, one should analyse both (Avgerou 2001). Therefore, this paper analyses the current socio-cultural context of design education before it presents a framework for the new generation of virtual design studios.

Sustaining reflective practice and experiential learning

Donald Schön's conceptualization of studio teaching has been widely used to understand the nature of design

education. In this view, design teachers are coaches or master practitioners who have expertise, and design students are novices who want to learn the process. Teaching and learning occur in a joint experimentation mode in which the teacher demonstrates typical design processes in continuous communication with the student. Several representations of design ideas, such as sketches, working models, schemes, and charts, are used in this exchange, which Schön (1983) calls "reflection-in-action". Waks (2001, 45) identified three tasks of coaching in Schön's framework:

> Dealing (alongside the novices) with the substantive problems of design, via combinations of moves/words, demonstrations/descriptions, in order to convey to novices the ability to deal with similar situations;
>
> Particularizing the demonstrations/descriptions to specific learners – that is, fitting esoteric moves and words into a dialogue with the novices' uncertain moves and words;
>
> Maintaining relationships with the novices: these teaching-learning relationships are fraught with problems because the novices can only learn by doing – but as novices they cannot yet actually *do*. The novices thus can be expected to experience feelings of loss of control, vulnerability, and enforced dependence. So coaches must cope with the predictable negative feelings arising in this predicament.

The above tasks indicate that face-to-face social interaction in the studio allows for a great deal of indirect communication. Therefore, the typical relationship between a design instructor and a student would be challenging to develop in a strictly virtual environment. Furthermore, experiential learning (Kolb 1984) is a key concept in design education; engaging with the material itself and developing ideas through sketchbooks, drawing, physical models, etc., and recording the process are essential. Some means of expressing design ideas, such as sketching and working on physical models (although supported by digital tools to some extent), still work better in the traditional studio environment compared to the conventional digital design media. However, it should be noted that virtual environments may support design interaction and intuitiveness.

On the other hand, some aspects of the current state of reflective practice in the traditional studio encourage its blending with Web 2.0 and cloud computing learning components. The interactive experience in the traditional studio has been criticized for cultivating student dependence on the instructor (Boyer and Mitgang 1996; Mitgang 1999). The dominance of the design instructor in the process can cause students to rely upon the instructor's ideas rather than on their own.

The student-centric approach associated with Web 2.0 tools (Jahne and Koch 2009) can lead to a shift in the locus of control between student and instructor in design education. Osguthorpe and Graham (2003) have indicated that using online learning in education allows students to review and control their learning. The concept of the nineteenth-century studio is transforming; students tend to work outside the studio and spend much more time engaging with their computers and mobile devices (Mizban and Roberts 2008). This change may help ease some of the pressure associated with increasing enrolment in design education. A cloud computing-based approach to design education would enable students to participate in studio activities using very little computer hardware (e.g. only smart phones) and without time or location limitations. This approach would expand the studio environment and bring flexibility to traditional classroom-based teaching.

Developing professional practice skills and working on the cloud

It has been widely recognized that design is a professional skill-based activity. The emphasis on project- or problem-based learning in the studio is also about simulating real-life practice. Design education presumably extends to the professional realm: being given and responding to a project brief, managing time and resources, collaborating with other team members, and articulating the language of practice (Logan 2006). However, it has been observed that design education institutions have been experiencing problems in developing such skills in students (Lewis and Bonollo 2002).

One of the major motivations underlying early virtual design studios was to promote collaboration with peers. Mitchell (1994) defined three paradigms of computer-aided design (CAD), and predicted that the third one (which he called "social CAD") would be the most important in the future: "There is a growing consensus that designing must be treated as a fundamentally *social* activity – a matter of multiple, autonomous but interconnected intelligences in complex interaction" (239). Mitchell's vision has been realized to a great extent. Now, design practice occurs in a global arena and designers are increasingly challenged to work in multicultural environments. Collaboration skills and cultural awareness have already become a part of employability requirements in design offices.

The current trend in professional design practice is characterized by self-organization of individuals into loose networks of peers to produce designs. Using Web 2.0 and cloud computing tools, individuals who have never met physically are collaborating to solve challenging problems that are "crowdsourced" to a community of interested parties. Current examples of crowdsourced design solutions include graphic design (CrowdSPRING Web Site 2013), product design (Quirky Web Site 2013), and software design (Topcoder Web Site 2013). For the new generation of designers, this paradigm will be the norm. Organizations are increasingly transforming into decentralized supply-and-demand networks. In such a framework, an organization's success is determined by its ability to integrate the intelligences of dispersed individuals and other

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organizations. Therefore, an aim of design education in this age should be to prepare students for new modes of practice. Rather than "delivering" information, helping students learn to create and wilfully regulate distributed value creation should be the focus of teaching methods. Virtual design studios as a means to develop students' collaboration, networking, and design management skills are needed now more than ever.

Theoretical framework for a blended and distributed virtual design studio on the cloud

The characteristics of design education entail that the framework of technology-mediated learning in a design studio should be significantly different from that in other educational fields. Having reviewed the available technology and changing socio-cultural context of design education, this paper proposes that a contemporary virtual design studio can be conceptualized as a distributed socio-technical system with participants and several mediating structures with different affordances. The term "mediating structures" belongs to Pea's theory of "distributed intelligence". Pea (1993, 47) discussed that "intelligence" and "cognition" are often conceived as a property of the minds of individuals in educational settings, but in fact, intelligence is revealed through activities that are distributed "... across minds, persons, and the symbolic and physical environments, both natural and artificial". These ubiquitous mediating structures include tools, symbolic representations such as drawings, models, and text, as well as people in social relations and features of the physical and virtual environment. He also argued that distributed intelligence is mediated by the design of tools and their affordance properties. "Affordances" in this sense refers to "perceived and actual properties of a thing, primarily those functional properties that determine just how the thing could possibly be used" (Pea 1993, 51).

In line with this theory, a contemporary virtual design studio not only blends the traditional studio with technological components but also utilizes a variety of tools with different affordances to augment distributed intelligence and learning processes. Within this framework, there may be five main means to achieve this goal in a virtual design studio:

(1) Augmenting intelligence by blending traditional and online techniques.
(2) Augmenting intelligence through affordance-based distributed tool usage: combining several tools with different features and capabilities.
(3) Augmenting intelligence with cloud computing and external representations: enabling mobile and convenient access to different representations of project-related information, such as text, computer visualizations, videos, simulations, and multimedia.
(4) Augmenting intelligence with situated cognition: exploiting features of social situations (like the connectivity of social media) as learning resources.
(5) Augmenting intelligence with guided participation: utilizing the design teacher as a facilitator who creates opportunities for students' self-controlled knowledge exploration and co-creation.

In the proposed studio, technology is not merely used as a means of teaching but for redistributing intelligence and exploring new uses of students' potential and participation. In the current context of design education, the new aim of studio teaching ought to be that of teaching for the design of distributed intelligence. This model differs significantly from earlier virtual design studios, which often utilized a single collaboration application and followed the one-to-one interaction style of the traditional studio. In a design studio on the cloud, a variety of tools are "blended" with the traditional design studio. Moreover, the use of new participatory tools allows for many-to-many interaction, which corresponds better to the new modes of design practice (Figure 1).

The model presented above was supported by the "flipped classroom" developments in higher education in recent years. The "NMC Horizon Report: 2014 Higher Education Edition" (NMC 2014) acknowledged the flipped classroom model as an emerging trend. In a flipped classroom, the ownership of learning shifts from the educators to the students:

> Rather than the teacher using class time to dispense information, that work is done by each student after class, and could take the form of watching video lectures, listening to podcasts, perusing enhanced e-book content, and collaborating with peers in online communities. (NMC 2014, 36)

The multiplicity of tools and the "digital curation" of information are key aspects of flipped learning (Ostashewski, Martin, and Brennan 2014) and previous research provided evidence that the flipped classroom approach promoted learning (NMC 2014).

The case study

Research setting and participants

Within the above framework, the author designed and implemented a virtual design studio that enabled collaboration between interior architecture students from Bilkent University, Turkey, and from East Carolina University, USA. All of the subjects were fourth-year students. Forty-two students (30 females and 12 males) participated in the survey. Their ages ranged from 21 to 26 years, and the mean age was 22.87 (SD = 1.47).

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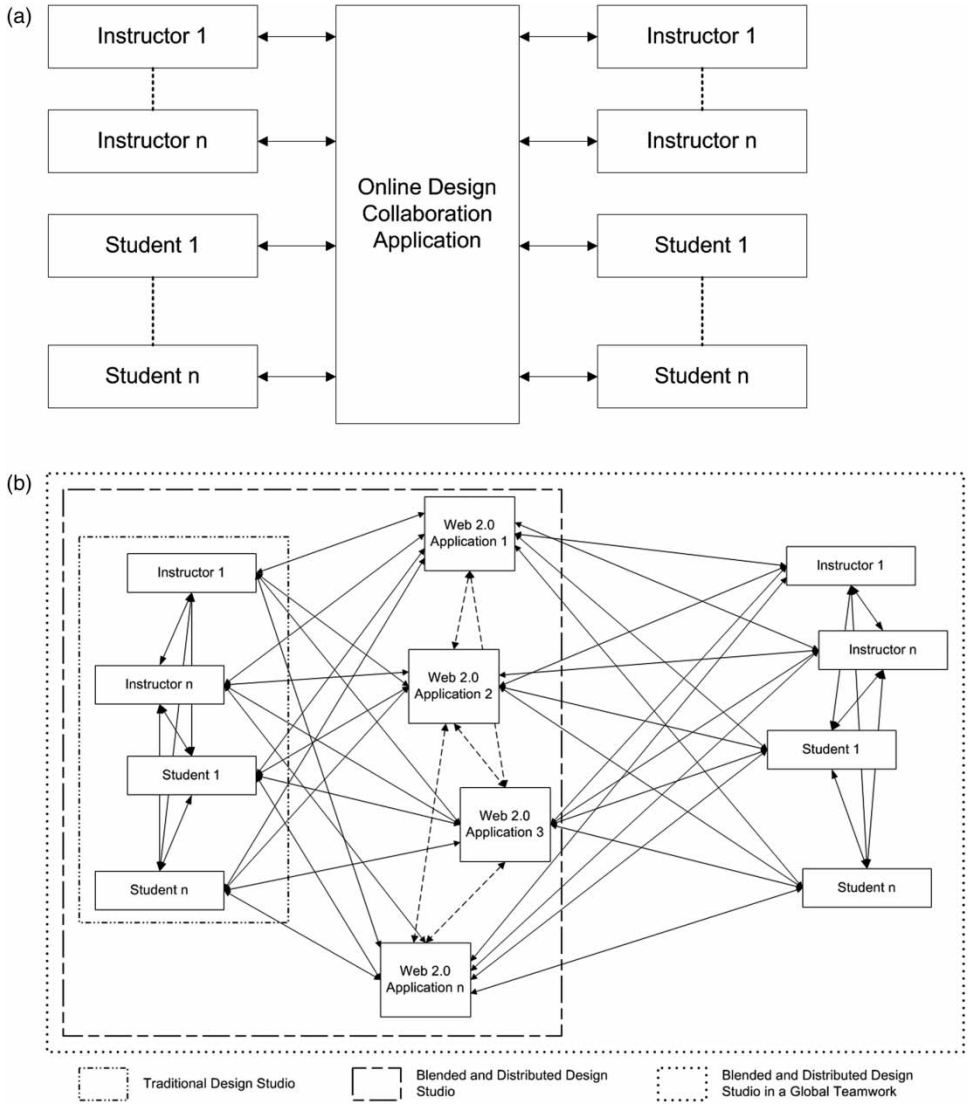

Figure 1. Interaction models of a conventional virtual design studio (a) versus the blended and distributed virtual design studio (b).

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Procedures

The project spanned five weeks in a semester and introduced students to new modes of professional practice with a particular focus on green and sustainable building design. The first module utilized only traditional face-to-face teaching and the second module comprised a blended approach of traditional and online education techniques. In the first module, Bilkent University students formed groups of five. They were encouraged to establish balanced groups, with evenly distributed creative, technical, and intellectual expertise. Each group's assignment was to design a partially self-sufficient unit in a specific climatic zone. The students conducted research related to the project, presented the research to the class, produced initial design ideas, and discussed the project with the instructors. In the second module, each team was paired with two students from East Carolina University who worked as green building consultants for their group. This role assignment aimed to simulate real-life global professional practice.

Distributed intelligence was augmented by the use of a variety of tools and the development of a "project cloud". The Moodle LMS (with its project database, discussion forums, and Wiki), videoconferencing systems (room type and Skype), and Facebook were utilized in the study. Schnabel and Ham (2013) discussed that social digital networks (Facebook or other participatory Web 2.0 tools) can be effectively used together with LMSs to develop a "Social Learning Cloud". The researchers recognized that: "Through active engagement in multiple SN [Social Networks], learning becomes a two-way experience: students act as both learners and researchers contributing to the body of knowledge." The conceptualization of the "project cloud" in this study is similar to that of Schnabel

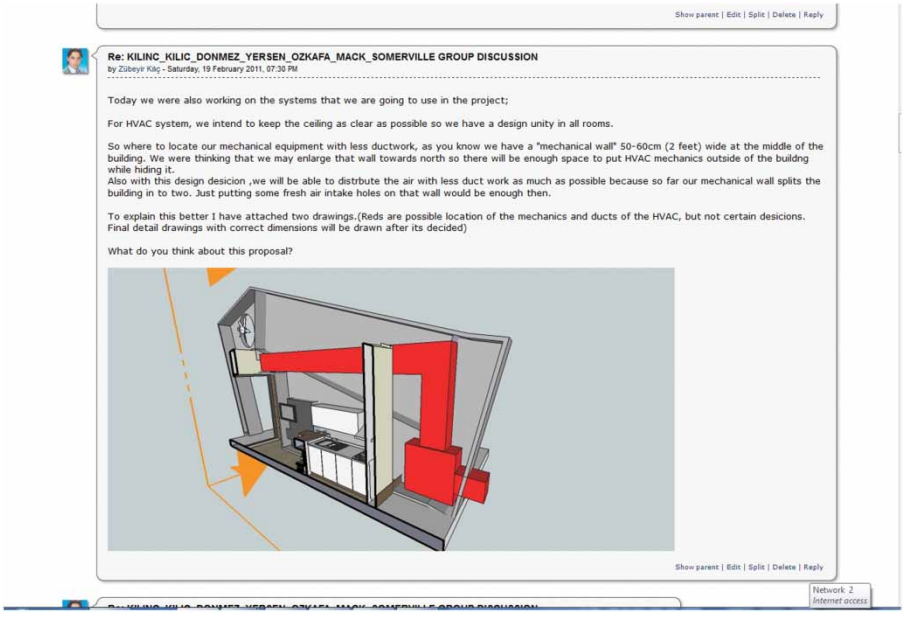

Figure 2. A snapshot from online discussions.

Figure 3. A perspective view of a design proposal.

and Ham's (2013) "Social Learning Cloud". The project cloud included all design-related resources (such as the project brief, research, case studies, and guidelines) like most of the earlier virtual design studios. Furthermore, students explored, shared, and co-constructed design knowledge in the form of online messages, sketches, images, drawings, videos, links to case studies and knowledge repositories, and any other means they proposed using the social networking media, the LMS, and Skype. This distributed, informal, and student-controlled learning experience characterized the present virtual studio which can be an example for further studies in this track.

Figures 2 and 3 present some samples of student work: a snapshot from online group discussions and a perspective view of a design proposal, respectively.

Data collection and analyses

To understand students' experiences in the case study, qualitative and quantitative approaches were applied. Two questionnaires (one with close-ended questions and the other with open-ended questions) were made available for all students who participated in the virtual design studio. Close-ended questions were asked to collect data on demographics. Open-ended questions were asked to investigate students' opinions about the benefits and challenges of the virtual design studio.

Response analysis was conducted using an established phenomenographic procedure (Yang and Tsai 2010). The participants' answers were pooled and analysed independently by two evaluators. Emerging themes were identified and then discussed to reach a consensus. Discussion and refinement of the thematic categories were an iterative process and continued until total agreement was reached. The same procedure was applied for all questions. To conduct quantitative analyses, students' responses were assigned to one or more categories. The final categories, their distributions, and the illustrative quotes from participants ascribed to the particular categories are presented in Tables 1 and 2.

Results

Participant background

The participants were asked to indicate their level of computer experience on a five-point Likert scale in which higher values denoted more computer experience. The results showed that the students rated themselves as experienced computer users ($X = 4.44$, SD $= 0.59$). The students were familiar with the Moodle LMS; all reported

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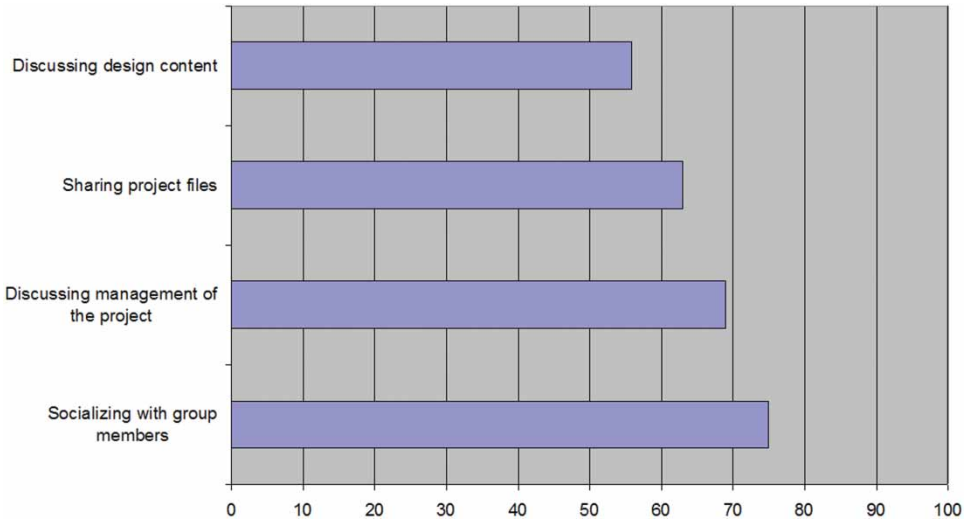

Figure 4. The percentages of the students' reasons for using Facebook.

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that they had used Moodle in at least one other course. All students had a Facebook account prior to the study and were regular users. The percentage distribution of the participants' daily Facebook use was as follows: 33% of the participants: less than one hour; 57% of the participants: one to one-and-a-half hours; and 10% of the participants: more than two hours. Among the several tools utilized in the study, the room-type videoconferencing was the only one new to participants; no one indicated that he/she had used it before.

Students' use of social networking media (Facebook) in the study

Seven of the nine groups (78%) reported that they used Facebook for the project work in the study to socialize with group members, discuss project management, share project files, and discuss design content (Figure 4).

Students' opinions about the benefits and challenges of the virtual design studio

The results of the thematic content analysis are presented in Tables 1 and 2.

Observations about the affordances of the tools used in the virtual design studio

The following observations about the tool affordances were made by the author. Although we believe that there is merit in discussing these observations briefly, further research is needed to reach more conclusive results. In the study, Facebook was satisfactorily used for many purposes as described in one of the above sections. However, the main reason for utilizing Facebook for project work was its widespread use among the students. Students preferred Facebook because in the words of one student: "All of our group members have already been there." Students widely use social networking media and this encourages its further educational uses. Videoconferencing was an efficient medium for group discussions and students appreciated its synchronous, interactive, and visual nature while communicating with foreign partners. The best functionality of the LMS during the project was its use as a course repository. The structured content in the LMS enabled easy access to course resources. On the other hand, LMS discussion forums were not perceived as a useful tool to communicate design ideas by the students. The students reported that the discussion forums were too formal and not intuitive enough.

Discussions and conclusion

This study revealed that the proposed model for technology-mediated design education was perceived positively by the students involved. Several participants mentioned that the design and implementation of the virtual design studio was well suited to their needs and preferences. Teamwork in design entails intensive sharing of design documents and ideas. For that reason, the project cloud utilized in the study was the most-liked aspect of the studio. The majority of students appreciated the mobile and convenient access to information and the opportunities for working on the cloud. Cloud-based collaboration tools will affect every professional business (Miller 2008), therefore, the learning environments in our study provided a setting for a rehearsal of future workplaces and helped prepare students for a global, networked, and competitive professional design practice. It should be noted that although this study utilized a role-playing scenario for this purpose, further studies can experiment with different scenarios like crowdsourcing.

Table 1. Participants' opinions about the benefits of the virtual design studio.

	n	% of responses	Illustrative quotations
The "project cloud" provided convenient access to different representations of project-related knowledge and to mobile design environment 7/24	31	74	"It was so easy to access information when demanded. The project work was really intensive." "We were able to work on our project no matter where we are and what the time is."
Consisted of the strengths of both online and traditional education techniques	23	55	"I think the blended approach is the best way of learning. We are accustomed to the traditional studio and we know that it is useful. Online techniques are helpful too. The combination worked well."
Enabled us to connect socially to our peers	18	43	"We made new friends and maintained relationships with the old ones." "The project enabled cultural interaction and socialization which I really appreciated."
The use of several tools in the virtual design studio was useful	16	38	"I think working with many online tools increased our motivation. It was a different experience in the studio." "We communicated through multiple channels and this accelerated project work."
Enabled monitoring other groups' process/files	14	33	"I was able to follow others' projects and files." "The online activities were good in terms of observing the other groups and their developments. This is not quite possible in the traditional studio."
Improved professional practice skills and prepared for future practice	13	31	"I think I gained many skills, collaboration and negotiation skills as well as cultural awareness." "This experience before graduation was useful for our future career."
It was fun	9	21	"It was really fun."
	42	100	"I enjoyed it a lot, so I was more willing to participate in the activities."

Table 2. Participants' opinions about the challenges of the virtual design studio.

	n	% of responses	Illustrative quotations
Management of the process was difficult	19	45	"It was challenging to catch up with what is going on." "Coordination of a group is always a problem. In this type of studio, it becomes more difficult."
Technical problems soured the experience	12	29	"Downloading large files was a problem." "I did not understand some parts of the communication during videoconferences due to the sound system."
Traditional studio should not be forgotten	8	19	"This was a good experience, but I think the traditional studio is an inseparable part of our education." "I believe that online studio cannot replace the traditional one."
Some instructors' involvement with online activities was not enough	6	14	"I would prefer to contact more with the instructors.
	42	100	"Some instructors did not participate in online activities."

Several students also indicated that blending a traditional studio with online components enabled them to benefit from both methods. Blended learning is already an important concept in educational fields (Garrison and Vaughan 2008), and several of its advantages, such as improved student performance (Lim and Morris 2009; Lopez-Perez, Perez-Lopez, and Rodrigues-Ariza 2011), motivation (Lei 2010), capacity for reflection (Cooner 2010), and greater flexibility in education (Macedo-Rouet et al. 2009), have been addressed in the literature. Despite

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the apparent benefits, however, there remains limited interest in applying blended learning to design education. This study indicates that considering the potentials of technology and its appeal to students, as well as the nature of studio teaching, a blended approach may be the best solution for the contemporary design studio. Online learning components can be used to complement – not replace – traditional methods. Our study also demonstrates that such a blended approach can be utilized to expand the studio beyond physical and time limits while preserving the essential qualities of traditional studio teaching.

In addition to providing an "environment" to work on the project, the virtual design studio also provided opportunities for participants to interact socially and culturally with their peers. It seems that this social interaction motivated the students who value being "connected" to their friends. The new generation of design students has already been extensively using social media and mobile computing, and this study effectively utilized situated cognition within social media as a learning resource. In fact, the capabilities of Web 2.0 and social media tools overlap with the priorities of design education. Education in art and design fields is essentially dialogical and social. Thus, Web 2.0 and cloud computing tools have the potential to further increase design education's already participatory approach. This study focused on proposing a framework for a virtual design studio on the cloud and on examining students' opinions about it. Further studies can analyse pedagogical issues in a more detailed way, for example exploring how Web 2.0 and cloud foster deep learning. Moreover, further research can also study the disadvantages and challenges of Web 2.0 adoption in design education.

The use of a variety of tools with different affordances was also perceived positively by the students and motivated them to participate in the studio activities. The survey results support the hypothesis that in the age of Web 2.0 and cloud computing, a single tool is no longer enough to support teamwork. In the virtual design studio, the complementary use of tools with different representational capabilities and synchronization modes enabled effective learning processes. Considering the ever-increasing multiplicity of digital design tools, affordance-based appraisal of such tools is a critical issue. Further research should focus on affordances and how these can regulate tool deployment in learning processes.

Several students mentioned that working with multiple online tools was "fun". Seeking fun and stimulation is a characteristic of the new generation of students (Tapscott 2009) and it is very likely that their enjoyment of the online tools contributed to the high level of attendance and participation in studio activities. The role of instructor in this new mode of learning is that of a "facilitator" rather than a "master". The teacher is expected to create opportunities for knowledge exploration and co-creation while acknowledging and respecting student autonomy. Further research could explore this shift in the locus of control between student and instructor in design education.

Another advantage of the virtual design studio in this study was the explicitness of the process. In the traditional design studio, design processes and students' documents are shared on a temporal basis. In this study, online tools enabled students to observe the processes of other students/teams and to be more aware of the project requirements. It should be noted that although this functionality was appreciated by most participants, a few students mentioned that they did not like such a level of accessibility/openness in the studio.

The most widely acknowledged challenge of the virtual design studio was managing the process. Due to the nature of the tools used, such studios require almost 24/7 participation and guidance. Although the educational process was carefully planned and structured before the term began, many problems arose over the five weeks and had to be resolved. Hence, further studies on the planning and management aspects of virtual design studios are much needed. Some communication and coordination problems were also reported, such as the time difference between Turkey and the USA, the difficulties in managing a group project with limited time, and problems with using the online tools. These issues should also be considered in further studies.

Although the proposed model for a virtual design studio was well accepted by the students, their views on traditional studio teaching were also very positive. Some students even indicated that traditional face-to-face education is an indispensable part of design education. In a sample of 2196 students from 29 Austrian universities, Paechter and Maier (2010) investigated under what conditions students prefer online or face-to-face learning components and concluded that "[t]he students preferred face-to-face contact when the discourse with the instructor serves to develop knowledge, e.g. when the instructor is to facilitate the acquisition of knowledge and the application of adequate learning strategies" (296). This argument is consistent with the role of studio instructors and can be an explanation for our finding. Nonetheless, further research is needed to highlight which aspects of the traditional design studio are valued by students and how these can be integrated with online learning components.

The virtual design studio also requires constructive involvement of the instructors. However, instructors may not be capable of participating in nor willing to participate in such studios. In our study, it was observed that some instructors were reluctant to integrate new methods into their teaching practices. Design instructors' resistance to new technology has been addressed by previous research (Pektas 2007). Robertson et al. (1995) defined three possible explanations for the negative attitudes of teachers towards computer applications. A major reason is conservatism and another is anxiety caused by having to introduce more innovation to teaching. The third

possibility is that teaching staff and students may have perceptions about such applications. Students may see them as utilitarian high-tech devices and teachers may perceive them as potential pedagogical tools that they are not adequately prepared to use. The success of efforts in integrating new technology with design education largely depends on each party's attitude. Thus, this paper suggests that instructor attitude is another issue that should be taken into account in further studies.

This paper proposed a theoretical framework for future virtual design studios and showed that it can be used to develop learning environments consonant with the changing socio-cultural context of design education. It is hoped that this work will facilitate further studies in this track.

Acknowledgements

The author would like to thank the students and instructors who participated in the virtual design studio.

Disclosure statement

No potential conflict of interest was reported by the author.

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