4 COLLABORATIVE DESIGN AND LEARNING IN STUDIO COURSES

While software platforms can facilitate design collaboration, project-oriented courses in university settings can play an important role in developing and sustaining a culture of design innovation in critical problem domains. However, such courses require a multidisciplinary approach to learning and cooperative design. Over the last 2 years, along with other graduate students and faculty at MIT, I have been involved in creation and teaching of an experimental design studio, “Design that Matters”. The studio course was run for the 2nd time in spring 2002, in conjunction with several similar studio courses at universities worldwide. To my knowledge few comprehensive studies of such learning and collaboration experiments have been conducted. Most experiments point to great challenges in the adoption and use of online tools in such settings for a variety of reasons.

4.1 Related Work: Online Collaboration and Learning in Educational Settings

With the proliferation of the Internet in schools and universities, there have been many attempts to integrate web-based collaborative technologies into educational curricula for more effective student learning. Three major initiatives at school and university levels are discussed here.

4.1.1 Learning and Collaboration in Schools

The WEB project\(^{46}\) for online learning among students at rural Vermont schools has been underway since 1995, as part of a statewide initiative. School students and teachers used an online environment to post, discuss and critique student review of literary texts and projects in multimedia, digital art and music. From 1998-2000 an evaluation study was conducted by the RMC Research Corporation [Sherry02] to assess the impact of the project on nine cooperating schools, using quantitative data from surveys, qualitative data from site visits and triangulated with analysis of online student products. Site visits included interviewing teachers, students and focus group discussions with students. Online surveys were administered over a three-year period to all 165 teachers, administrators and online mentors. Student surveys measured a variety of student attitudes, motivations, behaviors and skill areas. 165 students high school and middle school participated in the surveys.

Student surveys indicated that about 95% students reported that they posted products and revised them at least once. Most students posted multiple times, however many final products were never posted. Participating teachers were involved in developing and benchmarking rubrics to assess student products. The pattern of results showed a number of trends: 1) When a new technology is introduced there is a learning curve that lowers performance before the desired student skills begin to increase again. 2) Teachers observed improvements in student behaviors over time, with engagement, constructive feedback and increased metacognitive skills earlier while higher-order thinking skills like depth in reports were observed only later. 3) Most teachers found it too early to tell about improvements in student grades and test scores. Self-reported measures of motivation indicated students tended to be more engaged in WEB project classes than in the school activities. Pre and post-test student surveys showed some improvement in application of skills, however a slight decline in class motivation (attributed to the timing of the survey at the end of school year). Interviews and focus groups showed students willingly spending many hours learning and applying new skills, motivated by the technology rather than demands of the instructor. Students were found to be evaluating and improving their work. Student product assessments conducted by 143 teachers and juried by experts showed students nearly met pre-set standards for design and revision of the products they created, however no significant improvement was observed. The greatest challenge in such studies has been to establish clear linkages between educational technology and student achievement.

4.1.2 Nature of Collaboration in University Courses

Online tools for effective project-based learning in university settings have been developed and studied for a number of years at the College of Computing and the EduTech Institute at Georgia...
Tech. A succession of experiments on collaboration technologies and their introduction in classroom settings provide a mixed picture, highlighting some successes, but many failures and challenges in adoption and sustained usage by students. Team planning and facilitation tools such as CaMILE introduced to sophomore computer science and mechanical engineering students, showed poor adoption, usage and minimal content postings [Kehoe98]. Surveys and interviews indicated that students saw little benefit in the computer-supported tools, particularly when students already had a close working relationship with teammates. However, subsequent web-based versions of these tools allowed linking notes to threads in online discussions, producing longer threads vs. that of the same class using newsgroups (unanchored threads). Hence, a form of “anchored collaboration” supported in web-based tools encouraged extended discussions, which could contribute to learning.

CoWeb47 is a collaborative learning environment used in many classes at Georgia Tech [Guzdial02]; it is developed as a simple domain-independent collaboration tool that allows users to create editable webpages and embed online links or uploaded files. With minimal privileges, controls or user tracking, all users had equal access to add or change any existing content submitted to the site and ability for anonymous posting; one professor referred to it as a “whiteboard that everyone can write on”. However, all versions of the webpages are archived and can be restored when needed. CoWeb has been applied in nearly a 100 courses at Georgia Tech in domains such as architecture, computer science, engineering, mathematics and English. The tool seems to have been more readily adopted in English composition and design-oriented courses such as architecture studios, while there has been active resistance in engineering, mathematics and computer science courses. Evidence from interviews and questionnaires points to a number of sources for both support and resistance observed in different learning contexts.

4.1.3 Collaboration in Architecture Studios

CoWeb was employed in an architecture studio to encourage students to post and explain their designs online, facilitate access to online cases/resources, support peer-review and feedback from distant critics [Zimring01]. Students in the studio were assigned the same design problem, five chose to work in two-person teams while five others worked independently. Six professional critics were invited to participate, most of whom where geographically separated from the students. Students were asked to use CoWeb to create web pages with scanned drawings and text describing their ongoing designs concepts. They were also initially asked to create online journals with a record of considerations, evaluations, discussions, ideas and so on, easily accessible to all, so that the virtual critics could regularly comment on it. However, the researchers found that “casual interaction was not prevalent”. It was noted that the initial stages of design involved a flurry of ideas that were rapidly evaluated; when students put their thoughts in the journal they became too long and scattered, and most students were reluctant to commit initial conceptions publicly or take the effort to scan and upload all early designs. Most students eventually created online presentations (for the 3 formal reviews scheduled in the term) as linear narratives rather than add hyperlinks or organize them with multiple web pages in a nonlinear manner. Due to the effort involved in setting up online presentations, most were not continuously updated throughout the term; this meant that some of the design decisions made between presentations were left undocumented.

Critics experienced long delays downloading large documents on dialup modems. They preferred to understand the overall design context and products, rather than comment on early and changing design concepts. Most comments posted were encouraging; sharp criticism was never posted. Students did not always find the comments relevant as they had already moved on to other issues in their designs, by the time the comments were posted. Some critics complained that they were not sure their comments were “heard” as questions were never answered and there were long delays between student postings. Many students preferred to send critics email to describe details or seek specific advise. Most students did not post comments on each other’s designs online, either because they were not explicitly instructed to do so or they provided

47 http://coweb.cc.gatech.edu/csl
feedback to each other verbally, or their interest simply diverged over the term. They may not have seen a clear instrumental or learning value in doing so. Another reason cited was to do with the notion of “ownership” of the online projects, reinforcing a perceived distance among projects and freedom to comment on other’s online space. Structured reviews regularly scheduled were found to be effective, rather than unstructured online critiques. However, critics appreciated the ability to review and interact asynchronously on their own time, having the opportunity to consult material, prior work and carefully organize their comments before posting. Overall, the task of presenting design concepts in an online environment, forced upon students to continuously evaluate and revise their work, serving a critical role for better reflection and maturity of ideas.

4.1.4 Lack of Collaboration in Science/Engineering Courses
The adoption and use of CoWeb in some courses has shown a surprising active resistance to online posting and collaboration, particularly by science and engineering students [Guzdial01]. A number of interesting and sometimes perplexing behaviors were observed: In an experiment with students working on a joint problem in two mathematics and chemical engineering courses, 40% of the mathematics students accepted a zero on the assignment rather than collaborate with chemical engineers. In one 10 week semester, students in an architecture class generated over 1500 web pages while in the chemical engineering course, not a single student posted anything online; in a computer science course of 340 students only 22 students participated. In a mathematics course, even though researchers developed an online equation-editing tool, despite faculty encouragement not a single student ever tried it. The researchers feel that these trends indicate that it was neither the technology nor a lack of understanding of how to collaborate; if it were so there would have been evidence of students at least trying the technologies. But there seems to be an active resistance to the notion of collaboration itself, which explains these results.

In questionnaires and interviews researchers found that students often viewed the class or field as intensely competitive, while demanding a great deal of time and effort. Students “didn’t want to get railed” i.e. receive critical reviews and mentioned “with the curve it is better when your peers do badly”. Students often perceived that there was “only one correct answer” to homework problems even when faculty insisted it was not true. Hence, in such highly competitive courses, students found it only “rational not to collaborate or help others”, while those in design or English composition courses with open-ended and ill-structured problems tended to have greater group interaction, as demonstrated in earlier studies [Cohen94]. Researchers make several recommendations to encourage peer review, learning and collaboration in science and engineering courses: 1) explicitly encouraging group discussion and activities e.g. promoting debate around problem formulation, 2) gradually introducing collaborative tasks, initially with low-commitment, and 3) rethinking academic incentives such as course structure and grading.

4.1.5 Collaborative and Experimental Social Design Studios
Faculty at Carnegie Mellon University and Technical University of Delft, Netherlands taught joint courses in fall 2000, addressing problem formulation and product design with real-world projects and industrial partners [Subrahmanian01]. Assignments included design problems such as transportation systems for Pittsburgh and water/sewage treatment systems for Amsterdam. Shared lectures were organized through video exchange. Each week, students in both campuses were asked to present reports on related readings and their design solutions, communicating electronically (phone, email and chat). Students used LIRE48, an online document management system developed at CMU, which provides access control, notification, linking and search. During the course 25-30 students worked in 5 interdisciplinary teams, gave progress reports each week, and were each asked to present one lecture on design methods. Faculty and students were enthusiastic about the course, considering it valuable to collaborate with students having different perspectives and a preparation for future real-life scenarios. Though the course seems to have been successfully initiated, no formal evaluation has been conducted or reported in published

48 http://www.ndim.edrc.cmu.edu/papers/lire.htm
papers. The *Design that Matters* studio courses took a somewhat related approach and show many similar challenges in design collaboration, which I now highlight in the study I conducted.

### 4.2 Study of Collaborative Design and Learning in the MIT Design Studio

In the context of the MIT Design that Matters Studio, I initiated a three-part study that assesses the nature of collaborative design, learning outcomes and social attitudes of students, external participants and instructors towards cooperative initiatives, using online usage, questionnaires and interviews. The pilot study was conducted primarily at MIT in May-July 2002 and will be extended to participants in the studio course taught in Bangalore, based on preliminary results and refined methods. The study consists of online surveys, interviews, and case studies of design projects. This section reports on the first stage of the study involving the online survey. The summary of survey responses provides a partial qualitative assessment and preliminary understanding of key issues in learning and collaboration that were further probed in the intensive interviews conducted subsequently.

The survey was completed by 17 students who participated in the Spring 2001/2002 studio courses at MIT. The survey responses provide a preliminary and qualitative assessment of student attitudes towards learning and collaboration in this setting. The responses suggest a number of key themes for studio courses: 1) courses focusing on sustainable design through hands-on learning have a broad appeal among students, 2) an important element of such real-world design courses is establishing meaningful linkages with external domain experts and organizations, and providing students opportunities for fieldwork, 3) the success of such courses requires commitment from faculty to provide academic legitimacy and active involvement of instructors and domain experts in mentoring group projects.

For online collaboration platforms, the responses indicate: 1) online tools focusing on sustainable design are useful for sharing and archiving designs, and have a role in dissemination and problem solving however they are most valuable when teams or domain experts are not always co-located, 2) the overhead for usage by busy engineering students must be minimized by simplified interfaces and greater integration with existing channels of communication like email, 3) in addition to improved navigation, many users requested tools for asynchronous content updates and real-time chat. Overall responses suggest that users view design as a social process rather than only that of archiving and exchanging data.

#### 4.2.1 Goals of Online Survey

For the online survey there are two main objectives:

**A. Examine Nature of Collaborative Design Projects in Classroom Studio Courses**

   I. Background and prior experience/inclination towards collaborative design.
   II. Process, artifacts, tools and procedures used in ongoing design activity.
   III. How did they research, document, and negotiate design constraints?
   IV. How was peer-review solicited and influence design outcomes?
   V. Concerns about intellectual property, privacy or disclosure of design.

*Key Parameter of Interest: Social Process of cooperative design and incentives for open disclosure and review?*

**B. Examine Online Participation and Design Activity on ThinkCycle Platform**

   I. Prior familiarity, access and experience with online interaction.
   II. Incentives to post content online, regularity and nature of postings.
   III. How did online posting and peer-review influence design process/outcomes?
   IV. Barriers and constraints experienced that limited online interaction.
   V. Tradeoffs in the mapping of natural design activity to online interaction.

*Key Parameter of Interest: Why do we see a low level of adoption and online activity by participants in collaborative design projects? What are the barriers involved?*
Note: all assumptions and outcomes are based on a small group of design projects in a university setting and the use of an experimental online collaboration platform.

4.2.2 Methodology of Online Survey

The online survey consists of a questionnaire to solicit self-reported background, motivations and experiences in the design studio and online platform. The survey uses a mix of multiple-choice questions and open-ended questions. For many multiple-choice questions a Likert scale was used to provide a series of statements to which participants can indicate degrees of agreement or disagreement. The survey consists of 80 questions categorized into 5 sections: 1) demographic information, 2) general attitudes towards collaboration in courses, 3) evaluation of studio design courses, 4) online access and experience and 5) experience and usage of ThinkCycle.

The survey and interview protocols were submitted to the MIT Committee on the Use of Humans as Experimental Subjects (COUHES), in accordance with the following guidelines:

"Questionnaires distributed and interviews conducted for research purposes are subject to COUHES review. Questionnaires must state at the beginning that answering is voluntary and that there is no obligation to answer every question. There must also be a statement about confidentiality and anonymity. Interviewers must assure their subjects of the same rights and the right to discontinue the interview at any time."

The COUHES committee met on May 16, 2002 and reviewed the study proposal. The survey was revised to incorporate their suggestions, and was subsequently approved by the committee.

A survey questionnaire generation, administration and reporting system has been deployed on ThinkCycle. I have developed a comprehensive survey tool that allows investigators to setup online surveys with questions having multiple response options. All user responses are stored in the Oracle database in a secure manner. Cumulative survey results are automatically generated and displayed using graphs and anonymous text summaries.

The survey was pilot tested with one participant and refined before making it available to all other participants at MIT. All participants signed an informed consent form and most completed the survey in 30-45 minutes. All responses are anonymous and cumulative results automatically generated online are only released to participants who have already completed the survey.

4.3 Examining the Results of the Survey Evaluation

The following is a summary of responses from the online survey administered to students that attended the MIT studio design courses in 2001 and 2002. The summary is categorized into 5 sections (along the lines of the survey), with key survey results outlined and some preliminary interpretations of these results.

4.3.1 Demographic Information

Summarized results from the first section of the survey indicate:

- **Response Rate:** The online survey was completed by 17 respondents out of 18 participants solicited from the MIT DtM studio courses in 2001 and 2002 (94% response rate). Despite 80 questions asked in the survey (multiple-choice and open ended), there was a completion rate of 97-100%.

- **Demographics:** Of the 17 participants roughly 70% were male and 30% female with an average age of 28 years (standard deviation of 10). The participants were equally distributed across undergraduate, graduate, PhD Candidate, and Alumni categories. The response rate for 2001 was 41% (7) and for 2002 was 59% (10).

![Participant Demographics](http://web.mit.edu/committees/couhes/consent.htm)
split among undergraduate, graduate and PhD candidates (nearly a third each) with a small number of alumni attending (2 respondents).

- **Background:** Almost all respondents were MIT students and had technical backgrounds. Degree majors included a diverse mix of engineering fields (Mechanical, Chemical, Aeronautics, Biomedical and Oceanographic) along with some students from the Media Lab and one in humanities (English and Business from Harvard).

**Diverse but Typical Student Mix:** The overall demographics provide a range of respondents among undergraduate and graduate students with diverse technical backgrounds across MIT. The age and gender of respondents also suggests a fairly typical distribution found in advanced MIT courses.

**Broad Course Appeal:** The demographics of participants observed suggests that the studio course has appeal to a broad mix of engineering students throughout the university, rather than in any one discipline alone. This indicates that there would be student interest for such a course, offered institute-wide and/or incorporated in many engineering curricula.

**Small Class Size:** One may consider the students participating in the studio courses each year (9-12) to be a low number relative to standard MIT courses – this can be assumed to be either due to lack of publicity, novelty of the subject, lack of legitimacy (due to unofficial status of course) or lack of perceived integration into existing engineering curricula. On the other hand, the number of students participating each year may be considered entirely appropriate for a studio design course (offered for optional credit) not unlike seminar or special topics electives offered at MIT. However, there are indications (discussed later) that many more students would have participated if they had known about the studio course well ahead of time.

**Survey Response:** The high survey response rate and completion rate suggests enthusiasm to participate in the study. One student from the 2001 course reviewed the survey questions but declined to participate, despite my insistence. He explained that he felt a lack of confidence that his project and learning experience was successful enough to report in the survey.

**Note on Survey Response:** Overall, one must recognize that the total number of respondents available for this survey does not by any means provide a representative and statistically significant sample for rigorous quantitative analysis. Hence, the results gleaned from respondents in this survey (within the context of a small studio course offered at MIT) must be interpreted qualitatively to suggest potential behaviors and hypothesis for future studies on a larger number of courses and participants. These summary results are also useful for posing relevant questions in follow-up interviews with some of these participants, to better understand individual behavioral attitudes and motivations.

### 4.3.2 General Attitudes towards Collaboration in Courses

In this section of the survey, general attitudes towards collaboration were solicited before asking more specific questions in the context of the actual design studio and usage of ThinkCycle. The responses indicate a number of general attitudes (based on cumulative results):
Individual vs. Group Work: Questions 1 and 2 were setup to disambiguate preference vs. benefit of working in groups. It was expected that some students would consider group work beneficial, yet prefer to work alone for various reasons. In the survey 71% of the respondents disagreed that they preferred to work independently, while 100% indicated they found working with others more helpful. 94% also indicated that they found their last group experience enjoyable and worthwhile.

The high rate of positive attitudes towards the notion of group work (or collaboration) is not necessarily surprising, but serves as a notable point as we examine to what extent did students actually work in groups over the course of the design studio, and how much did they benefit from such collaboration. This also bears on the level and nature of online interaction, sharing and peer review that one might expect to see among these students using ThinkCycle.

Perceived Barriers for Open Sharing of Design: The survey examined three specific perceived barriers to sharing – competition, maturity of ideas, and effort involved.

Role of Competition: Question 4 was used to determine if perhaps the perceived competitive nature of a field might induce lower incentive among students to collaborate or share evolving designs openly (within and outside the class). 42% of the respondents viewed the field of their design project as intensely competitive.

One must note that most students did not take the course for credit; hence there would have been little academic competition to receive better grades. Later in the survey, only 12% felt the course to be intensely competitive among students taking it. However, as the projects may have impact in real-world settings, some students may perceive a level of external competition. Question 5.A. also solicit a response to whether students may not share openly due to such competition. However, only 12% of the respondents were concerned that they would not share project designs openly because others may use their ideas without benefit to them.

Maturity of ideas and effort involved: It was expected that many respondents would feel uncomfortable sharing premature ideas, however only 24% perceived this as a barrier. Similarly only 24% felt it took too much effort to share project designs openly. Overall it seems that 76-88% felt that none of these three factors prohibited them from openly sharing their project designs. Hence we need to carefully understand why the respondents later do not actively seem to share their designs online at a level that one would expect.

1. I prefer to work independently on design projects rather than in groups.
   - Agree: 24% (4)
   - Neutral: 6% (1)
   - Disagree: 53% (9)
   - Strongly Disagree: 18% (3)

2. Working with others on projects is more helpful than working alone.
   - Strongly Agree: 59% (10)
   - Agree: 41% (7)

3. The last time I was involved in a group project, I found it to be an enjoyable and worthwhile experience.
   - Strongly Agree: 82% (14)
   - Agree: 12% (2)
   - Neutral: 6% (1)

4. I view the field of my design project as intensely competitive.
   - Strongly Agree: 24% (4)
   - Agree: 18% (3)
   - Neutral: 47% (8)
   - Strongly Disagree: 12% (2)

5. I don’t want to share my project designs openly because:
   A. Others may use it without much credit or benefit to me.
      - Agree: 12% (2)
      - Neutral: 53% (9)
      - Disagree: 29% (5)
      - Strongly Disagree: 6% (1)
   B. My ideas are too premature for others to review.
      - Strongly Agree: 12% (2)
      - Agree: 12% (2)
      - Neutral: 6% (1)
      - Disagree: 59% (10)
      - Strongly Disagree: 12% (2)
   C. It takes too much effort.
      - Agree: 24% (4)
      - Neutral: 24% (4)
      - Disagree: 41% (7)
      - Strongly Disagree: 12% (2)

Figure 4.2: Attitudes towards collaboration.
4.3.3 Evaluation of Studio Design Course

In this section participants were asked to reflect on their experiences with the studio design course they took at MIT. The section consisted of 24 multiple-choice and 4 open-ended questions. Of the respondents 41% took the course in 2001, where as 59% attended the 2002 course.

Why students took the Design that Matters Studio Course? 4 main reasons cited:
- Exposure to real-world problems and globally relevant social/developmental issues.
- Opportunity to work on practical design projects and learning by doing.
- Access to technical resources, a simulating environment and learning with peers.
- Lack of similar design studios in their own curricula or means to address social concerns.

General Evaluation of Course

Regarding the outcomes of the course, 71% agreed that the course exceed their expectations of learning, 88% felt it changed their approach to socially conscious design, 82% felt it provided them with valuable experience and real-world skills, and nearly all respondents (94%) mentioned that it gave them a good understanding of real world problems and challenges.

Relative to other project-based courses taken, 64% of the respondents felt that they learned more in this design studio while only 25% found it more difficult and 38% found it more time consuming.

It must be noted that there could be a slight bias in the reporting by respondents as the survey was administered by a course instructor (though responses are anonymous). However in open-ended questions later in the survey, most respondents did not shy away from critical feedback.

One interpretation of the responses points to the fact that the material learned in the course and through the design projects is not significantly covered or available in other courses at MIT. This points to a compelling need for offering similar design studios among many departments and enhancing existing curricula to incorporate elements of socially conscious or sustainable design. It may also indicate a greater level of learning through exposure to real-world problems, practical projects and peer review.

Beneficial Role of Guest Speakers, Domain Experts and Peers: In the survey, 95% agreed that guest speakers were engaging and insightful (71% agreed strongly). 76% found their interaction with external domain experts to be productive, while 65% agreed that peer reviews and collaborations were helpful towards their projects. Finally, 88% found the course instructors to be helpful in teaching and mentoring projects (53% strongly agreed). Hence, the diverse participants involved have a valuable role in the success of such a studio design course, particularly one with such a real-world focus.

1. General Evaluation of Course:

   A. Exceeded my expectations for what I had hoped to learn?
      - Strongly Agree: 47% (8)
      - Agree: 24% (4)
      - Neutral: 29% (5)

   B. Significantly changed my approach towards socially conscious design?
      - Strongly Agree: 47% (8)
      - Agree: 41% (7)
      - Neutral: 12% (2)

   C. Provided me with valuable experience and skills for real-world projects.
      - Strongly Agree: 53% (9)
      - Agree: 29% (5)
      - Neutral: 12% (2)
      - Disagree: 6% (1)

   D. Gave me a good understanding of the problems and challenges in designing appropriate technologies in the real world.
      - Strongly Agree: 53% (9)
      - Agree: 41% (7)
      - Neutral: 6% (1)

2. Relative to other Project Courses:

   A. How much do you think you learned?
      - Much More: 35% (6)
      - More: 29% (5)
      - Same: 29% (5)
      - Less: 6% (1)

   B. Found this to be a difficult course?
      - Strongly Agree: 6% (1)
      - Agree: 19% (3)
      - Neutral: 19% (3)
      - Disagree: 38% (6)
      - Strongly Disagree: 19% (3)

   C. How time-consuming was this course?
      - More: 38% (6)
      - Same: 50% (8)
      - Less: 13% (2)

Figure 4.3: General evaluation and comparison with other project-based courses.
Experience with Design Projects:

How did students find design projects?
4 main approaches for finding projects:
- Prior interest in a specific problem or area (35%)
- Through joining other classmates (28%)
- From challenges posted on ThinkCycle (17%)
- Speaking with a domain expert (11%)

The instructors had expected that the majority of projects would be selected from the online database, however it seems that personal interest and domain experts have an important role to play in providing ideas or motivation towards projects. It also indicates that instructors must recognize that many people will simply prefer to join others in well defined projects, rather than soliciting their own; this suggests instructors make a greater effort to steer students towards compelling projects and teams.

Who contributed the most to the projects?
71% of the respondents felt that over two people contributed to the project. Since most teams consisted of no more than 3 people, this suggests the role of external peers, domain experts and mentors in such design projects. 53% felt that their team members contributed the most while 29% felt they themselves were the primary contributor.

Time Spent on the Course and Projects:
77% of the respondents attended the majority of the course sessions and most spent at least 3-5 hours per week on their projects outside class. 88% agreed that they wish to continue working on their projects after the course is completed. This suggests that participants feel personally motivated to engage in their projects, regardless of the requirements of the course (note that most students did not take this course for credit).

Perceived Impact of the Projects:
Most respondents agreed that their projects had great potential for critical social impact (59% agreed strongly), while only 36% agreed that their projects had monetary value in the real world. Hence, a key motivation driving students was the perceived social impact of their work, rather than course credit or potential monetary incentives.

Best Outcomes of the Course Reported by Students
Summarizing the best outcomes mentioned by respondents: (in no particular order)
- Meeting accomplished practitioners, instructors and like-minded people in the field.
- Awareness and appreciation of problems faced by communities in developing countries.
- Learning social aspects of design and broader social issues in development.
- Collaboration with motivated students across different disciplines.
- Seeing a concept idea develop to a working prototype that tackles a real-world problem.

Figure 4.4: Experience with design projects – perceived impact, time spent and contributions.
- Recognizing technical, social and political challenges in bringing products to market.
- Winning top awards in design competitions or receiving patents from course projects.

**Suggestions for Improving the Design that Matters Studio:**

**People**
- Engage a network of faculty members at MIT (working in related areas) to be more involved in the course or actively supervising projects.
- There should be more instructor involvement with projects. Make sure mentors assigned to projects are actually available to work with the teams.
- Make more time available with external domain experts and speakers and less frequent in-class critiques (valuable but repetitive when progress on projects was slow).
- More emphasis and assistance with connecting to organizations that offered design challenges. Have field visits perhaps prior to beginning of class.
- Enhance access to final users of the design project, to get better feedback and iteration.
- Initiate social events and create more class spirit to encourage students to mix socially, and feel part of a supportive community.

**Tools and Resources**
- Easier to use tools for collaboration – posting and browsing was not as fluid as expected.
- Setup a library of source material accessed by students over time, to benefit future students.
- Make tutorials available on various subjects such as programming, electronics etc.

**Course Structure**
- The course should be offered for credit so that students may spend sufficient time on projects instead of hurting their academic time. In one survey question, 94% of the respondents (82% strongly) recommended the course be offered for credit to all students as part of the university curricula. However, one student disagreed, as she felt it should not be required unless people actually have an inclination to work on socially conscious design projects; her reasoning was “to ensure students who register, do so because they are serious and passionate about the topic.”
- There should be a more concerted effort to publicize the class campus-wide, as many students would have liked to take it had they known about it sooner.
- Better organization in the required readings and the class assignment schedule.
- Some undergraduate students suggested the course be more structured and lectures better organized e.g. “Sometimes class sessions seemed like they were strung together without much thought beforehand”. Graduate students preferred the open-ended format.

**Course Content**
- A more serious commitment to ethnographic research before design; many projects would benefit greatly from that.
- Investigate broader scope of projects including political, social and economic models (particularly in non-profit settings).
- Instruction on Media Lab machines and tools earlier in the semester.
- Have video footage of challenges available for students to review; it is more appealing and compelling than verbal descriptions on the website.

**Design Projects**
- Encourage more team building to make people comfortable to share their thoughts and visions without feeling ridiculed.
- Assign groups based on problem domains of interest and ensure diversity by mixing people with different skills, instead of waiting for groups to form naturally.
- Enforce stricter rules about project deadlines.
- Spend more time in the beginning discussing potential projects in class, rather than expecting students to find projects on the website or on their own.
Instructors should do some background research on potential projects and initiate contact with domain experts, and present well-posed projects at the beginning of the term. This will allow students to get started with projects sooner.

### 4.3.4 Online Access and Experience

In this section, participants were asked about their access and exposure to the Internet and collaborative technologies.

**Good Internet Access and Experience:** The responses indicate that nearly 90% of the respondents considered themselves proficient with the Internet and had fast access. All respondents browsed the web and check email several times a day, while many occasionally used online chat. Hence, lack of access or experience is less likely to be a factor in explaining the nature of online interaction for the participants at the MIT design studio.

**Regular Usage of Different Online Modalities:** Comparing different modes of access, email and web usage appears to be similar, while there is a wide distribution of how often some users use instant messaging (daily or weekly). Over 50% do not use instant messaging. Understanding modes of access is important to recognize the ways in which people work and naturally communicate with others on a regular basis. These patterns would suggest that collaborative tools for sharing ongoing design, must also integrate with such modalities in different ways. For example, some participants may prefer to receive email notifications and upload designs via email, instead of using the website. Some may wish to use an instant messaging channel to discuss design instead of using online discussion forums on the web. Though the survey responses in this section suggest some rough trends, detailed responses later provide greater evidence towards this hypothesis.

**Lack of Experience with Online Collaboration?**

Among the respondents, 65% had previously created their own websites or webpages. In an open-ended question, most respondents mentioned that they used web-authoring tools such as Microsoft Front Page or Macromedia Dreamweaver, while a few indicated they hand-coded html themselves. Regarding collaboration tools, only one person mentioned tools such as Netmeeting, Chat and Cu-SeeMe and another mentioned using Swiki (shared web-authoring). Most respondents did not indicate any prior experience with online collaboration tools, besides using ThinkCycle. It is entirely possible that they have indeed used such online tools, but simply did not perceive them as being “collaboration tools”. Given their primary backgrounds in engineering (vs. computer science) where much of their design activity is hands-on and face-to-face, many of these respondents may not be naturally inclined to using collaborative software tools like ThinkCycle, particularly on a regular basis in design courses. Hence, the notion of online collaboration itself may be considered a novel activity for most participants. Detailed survey responses in the next section point to similar attitudes. This indicates a greater need for familiarizing students both with online tools and collaborative processes early in the term, and finding ways to make online sharing a natural part of their design activity.
Experience and Usage of ThinkCycle

In this section participants were asked to reflect on their experiences with the ThinkCycle online collaboration platform, used during the MIT design studio. The section had 15 multiple-choice and 13 open-ended questions.

In summary, all respondents indicated that they had used ThinkCycle during the course. Of the respondents, 59% visited the site at least several times a week and 82% believed it is a useful online tool. However, the frequency of postings was much lower than expected (only 31% posted content several times a week). In terms of general usability, 53% found it complicated and confusing and 30% found it very time-consuming to use.

Let's consider the responses in more detail to better understand behavior and attitudes towards online collaboration and the ThinkCycle platform. A key question is - What prevents participants from using an online tool such as ThinkCycle more actively? The poor usability of the tool, unfamiliarity with online collaboration, lack of perceived value of engaging in online interaction or simply a lack of time in a demanding project-based course?

ThinkCycle Usage

As part of the Design that Matters course, all students were expected to post project-related content on ThinkCycle on a regular basis; we expected that most would browse the site every week and post content a few times a week to maintain an updated project archive and solicit feedback. The survey indicates that only 18% of the respondents browsed the ThinkCycle site everyday, while 59% visited several times a week. A critical point is that only 31% posted content on the site several times a week. The question is what sort of content was frequently posted and why? What prevents more active usage of the online site? Aggregate statistics and individual usage data are logged in the ThinkCycle Oracle database, and can be analyzed further if needed. In the survey we primarily try to examine individual attitudes and perceptions towards online collaboration (rather than precise daily usage), particularly in the context of ThinkCycle.

ThinkCycle Usability

53% of the respondents found ThinkCycle complicated and confusing to use, while 30% found it very time-consuming. It must be noted that only 2 respondents (12%) had previously mentioned any prior experience with online collaborative tools. A tutorial on ThinkCycle was made available to students at the beginning of the spring 2002 term. Hence, in the survey 59% of the respondents (10 students) who took the 2002 course had access to the tutorial, and 60% of those (6 students) reviewed it. Half of the respondents that reviewed the tutorial in 2002 found it useful, while 53% of all respondents found it necessary to ask instructors or peers on how to use...
ThinkCycle. With this basic summary of the responses on usability we will later consider detailed responses to better understand the key reasons preventing more active online interaction.

**Perceived Contribution of ThinkCycle**

Most respondents (83%) agreed that ThinkCycle is a useful online tool (47% felt strongly). 77% agreed that using ThinkCycle contributed towards their design projects. Finally, 82% felt that they would like to use an online collaboration tool for design projects in the future. Hence, there is a perceived useful role for such online tools in design, however for a number of reasons participants did not fully utilize and engage with the online platform in the studio courses, though they still found it beneficial in their design projects.

More specifically, 70% found viewing and searching content on ThinkCycle useful vs. 57% found posting content useful. In terms of reviewing content, a slightly lower number (44-51%) found both posting reviews and comments from others equally useful. Based on these responses, the main useful aspects include:

1. An easily searchable and indexed repository of ongoing design content.
2. The ability to post content ongoing concepts and resources on projects.
3. Commenting and reading reviews on content posted.

Now we consider more detailed responses underlying individual attitudes towards each of the three themes.

**Useful Aspects of ThinkCycle: 4 Perceived Views**

Respondents articulated several different perspectives of what aspects of ThinkCycle they found most useful. Their responses suggest four key functional views:

**A. Shared Group Space:** All respondents mentioned the notion of a “shared space” for exchanging files, documents and resources with teammates. In particular they liked the ability to easily upload large files and have the system automatically present their files on the web for easy access to everyone. Being able to notify teammates and coordinating reviews was helpful. Finally, some liked maintaining a private exchange within the team, while disclosing content publicly later.

"Sharing large files with specific members of the group … and (email) notification when files were uploaded."

"The 'ThinkSpace' tool was very helpful for my project. It was nice to have an online space to put all my files and resources and have it accessible for others to view."

"It was pretty powerful as each project could have its own shared space where people could post their documents and design. It was comparable to (or better than) commercial applications that I use at work today for professional collaboration."

**B. Viewing and searching content on ThinkCycle is useful.**

- **Strongly Agree:** 29% (5)
- **Agree:** 41% (7)
- **Neutral:** 24% (4)
- **Disagree:** 6% (1)

**C. Posting ongoing resources, links and concepts for my project on ThinkCycle is useful.**

- **Strongly Agree:** 38% (6)
- **Agree:** 19% (3)
- **Neutral:** 44% (7)

**D. I like reviewing and commenting on content posted by others.**

- **Strongly Agree:** 13% (2)
- **Agree:** 31% (5)
- **Neutral:** 44% (7)
- **Disagree:** 13% (2)

**E. I find comments posted by others on my content useful.**

- **Strongly Agree:** 13% (2)
- **Agree:** 38% (6)
- **Neutral:** 50% (8)

**F. Using ThinkCycle contributed towards my design project.**

- **Strongly Agree:** 12% (2)
- **Agree:** 65% (11)
- **Neutral:** 18% (3)
- **Disagree:** 6% (1)

**G. I would like to use an online collaboration tool for my design projects in the future.**

- **Strongly Agree:** 35% (6)
- **Agree:** 47% (8)
- **Neutral:** 18% (3)

*Figure 4.7: Perceived ThinkCycle contribution.*


“It helped us coordinate certain aspects of the research we were doing, and allowed the team to review drafts of documents.”

“Ability to make posting private to a few team members only and then open it to the broader community when the project is completed rather than open the entire time.”

B. Evolving Project Repository: Another notion commonly expressed is that of an evolving file repository or documentation tool that allows people to capture the ongoing progress of a project. The system allowed version tracking of files and documents, enabling the team to recover the history of project without losing earlier work. This view is somewhat distinct from a “shared space” in that it suggests a temporal evolution and permanence of individual or group project memory.

“A webspace for documents… simple upload and auto document presentation. I do not have to manually code everything. It is like an iterative web building tool for documenting a project.”

“A great site for archiving our on-line resources, references and project data files.”

“I found that ThinkCycle was a great documentation tool for the project. It also was very helpful in showing people what I was working on without having to explain myself various times.”

“(ThinkCycle) was an additional commitment to make a ‘permanent’ public presentation. As the final project had to be posted on the web, we had to think in terms of the archive.”

“I really like the version tracking feature, which guarantees that I can always recover my latest file version even if someone edits the "master" copy.”

C. Problem Solvers Area: Some users viewed the site in terms of finding “challenges” and solving problems (not only sharing or documenting), which provide learning in the design process.

“It’s a problem solvers area. Engineers and other people who love to solve problems should check out the stuff on ThinkCycle; there’s a lot of interesting stuff going on over there and especially the kind of problems which directly affect human beings. In solving such problems there’s a lot of satisfaction involved.”

“I found out about my initial cholera project on ThinkCycle. Also later on, it was useful to find out about the potential resources we could access.”

“To browse all of the different real world issues posted.”

“The fact that I can find out about the needs and the answers for those needs in the same webpage.”

“It was also pretty cool to look at all the challenges on the site and see which ones I would be interested in working on.”

D. Open Social Space: Respondents wanted to look at content posted by others, keep track of others progress, make people aware of their work and find relevant experts in certain areas. Many expressed a need to have others review their design projects (though it did not always occur). Social interaction in an openly accessible content space plays a critical role here.

“To look up links other team members posted.”

“The ability to find out what other people in this space are working on.”

“Giving the URL to interested parties so they can look at what our team is doing.”

“Ability to locate people interested in precise issues or have expertise in certain design areas.”

“… There’s also the part about exposure - when I presented my project to the class and the online community in ThinkCycle.”
"... Finally, companies contacted us to patent our idea, thanks to ThinkCycle!"

"It would have helped more if there were more people actively monitoring my project on the site and trying to find information for me."

These perceived views of the site suggest 4 distinct functions expected by the users, which clearly intersect during regular usage: **Coordination** (Shared Group Space), **Documentation** (Evolving Project Repository), **Learning** (Problem Solvers Area) and **Social Interaction** (Open Social Space). Such aspects play an important role for collaborative design in distributed settings.

**How and when was ThinkCycle used in the design process?**

**Modes of Usage:**
- **Gathering Resources** – users continued to informally search and gather online resources and add them to their project spaces throughout the design process.
- **Asynchronous Collaboration** – posting files and working documents for collaborative revision among teammates, particularly for large files not easily handled over email.
- **Distributed Collaboration** – exchanging ideas with teammates and domain experts in physically disparate locations, particularly when some were working on the field.
- **Soliciting Open Review** – posting concepts and ideas to gain iterative feedback from peers and a broader audience on ThinkCycle.
- **Course Awareness** – browsing the course site throughout the semester to check on class assignments, readings, schedules and guest speakers.
- **Lurking** – casually browsing project spaces to learn what people are working on.

**Temporal Phases of Usage:**
- **Pre-project Gathering** – collecting and organizing requirements, resources and background research in the early phase of the project.
- **Setting up Projects** – once a project was better defined, users setup “ThinkSpaces”, added members and posted “Challenges” in their newly organized project space.
- **Posting Completed Work** – uploading a week/month’s work after finishing a phase of the design or project work (e.g. CAD models, presentations or write-ups).
- **Design Review Updates** – most teams uploaded project-related files and updates right before the formal design reviews held in class.
- **Documenting** – though this ought to be an ongoing activity, many respondents mentioned that they seriously began documenting their projects towards the very end of the term, under pressure from the course instructors.

**Situations where ThinkCycle was not considered useful in the design process?**

Several respondents also mentioned reasons why they felt the online platform did not contribute as much to their design projects. Let's consider the key issues in their comments below:

"The team could function and work well without ThinkCycle but it was a useful tool for posting our final designs."

"For my project, I had the advantage of having a terrific domain expert available on campus. Therefore, our interactions were mostly personal (which was a lot quicker than if we had used the web). However, we did share some information that was posted on the web and that was really helpful. Especially background information was good to post on the site."

"(ThinkCycle) did not contribute much - there wasn’t much external input on our design concept. What helped most was non-website related approaches like our expert panel."

"We only used it at the very end, so it wasn’t part of our design process at all really."
I think it helped in that others could post information. I only had a couple instances where that happened though. It would have helped more if there were more people actively monitoring my project on the site and trying to find information for me.”

“On the project itself, it (ThinkCycle) was not so much of a resource as an additional commitment to make a ‘permanent’ public presentation.”

Summarizing the key issues:
1. Physical proximity of teammates and domain experts for personal and face-to-face interaction minimized a perceived need for online interaction (though we find others who still found it valuable for asynchronous interaction and project archiving).
2. Lack of people actively monitoring projects online provided less incentive for users to post content.
3. Overhead of posting content was perceived as an additional commitment rather than a natural or integral part of the design process.

These responses are reiterated in the survey question that followed (below), however most mentioned “time” as the most compelling reason for their lack of active interaction.

**What prevented users from posting content on ThinkCycle?**

User responses point towards 6 main issues: (in order of frequency)
1. “Lack of Time” – response most often cited. (50%)
2. Being in regular face-to-face contact with team members and domain experts. (18%)
3. Posting content took too many steps; need a simpler interface like sending email. (12%)
4. Low site traffic or lack of users actively monitoring projects online. (12%)
5. “Critical amount of interesting content not quite there.” – one respondent.

A more reasoned explanation by one respondent suggests that the nature of online usage changed over the course of the design project:

“Depends in fits and starts of a project. For certain periods, I would hardly post, but during an intense project session, I would post a lot of content.”

Several responses suggested the need for simpler interfaces, integrated into existing modes of communication:

“Time consuming and not following natural patterns of our behavior (email communication, etc.)”

“Just don’t get around to doing it - Not always at a computer, when I have my brainwaves… logging in, loading up website and then typing seems like a task - it would be a lot easier if I could email my updates out to a centralized system that pasted them online on my ThinkSpace…”

“If I think about the barrier to entry to another method, email:
1. My email program is open at all times. For ThinkCycle.org, I have to open up that specific page.
2. I have to navigate through the site and find the appropriate subject to post my comment or cross link. Then I have to delete some text in the form and then submit. In email, I just write a subject, paste in the link/ write the comment and send it off. In summary I think it comes down to convenience and a saved 30 seconds per event.”

Several respondents reason as to why they prefer not to engage in online discussions:

“Too much of a hassle to log onto forum everyday.”

“I generally stay focused on the projects I have right in front of me. I may login and surf to see what other people are doing, but I'm more inclined to answer questions posed directly to me than to enter a general chat room discussion.”
I have never used a discussion forum before. I think discussions are suited to certain individuals and I'm not one of them. I don't think there is anything wrong with this implementation - it's just personal preference.

Another respondent blames the interface and navigation for his lack of comment postings:

…Navigating the site. Lack of a visual map of where a project is at, and lack of a way to get to the parts I am likely to want to comment on quickly and intuitively.

What aspects of ThinkCycle were difficult to use?

Summarizing users responses, we find 4 key issues pertaining to usability, the majority of which have to do with site navigation and structure (rather than system robustness or functionality).

Site Navigation: 65% of the respondents encountered navigational difficulties while browsing the site, which can be categorized into two main types of problematic navigational experiences:

1. Traversing a Maze: Browsing a series of hierarchical menus and not being able to return to previous points in the hierarchy.

   (I) can’t easily go back in tree hierarchy. From: menu1 > menu2 > menu3 > menu4 > menu5, it is usually difficult to (go) back to where one once was.

   At first it was very confusing to navigate around the site, especially to find my ThinkSpace… However, with time, using the site definitely becomes easier.

   You do need to click in and out of various areas, though there are many opportunities to take short cuts once you learn the navigation system… When I first navigated the site, I didn’t find it frustrating to use - it was like a maze and I just kept clicking until I found something interesting.

2. Disorientation: Some users were unable to find content they posted or found themselves lost somewhere on the site; they did not seem to have a coherent spatial map of the site.

   Sometime it’s difficult to actually know where you are as in what part of ThinkCycle you are in. It would be nice to know where you actually are and how you could go to other sections.

   Once in a while I had a hard time locating where I or another team member had posted something.

   Similar kinds of content could end up in vastly different places, leaving us to follow branches fruitlessly.

   There were no clear ways to see the stuff on a top level--there were too many clicks to get what you wanted and no good ways to have a broader overview.

Both of these experiences are not uncommon on many large and complex websites (though it is rarely studied and reported on such sites). Most users, like the respondents here, gradually learn the overall structure and navigational short cuts to effectively browse the sites over time. However, simple and intuitive navigation seems to play an important role not just for browsing information but also enabling sustained usage of a collaboration platform. Hence, one must consider appropriate solutions to address navigational issues that increase user participation.

Organizational Structure: 31% indicated that the organizational structure was non-intuitive, i.e. hierarchical layers, categorization, and terminology on the site. The “Filespace” referred to here is a web-based hierarchical file directory, an existing software module integrated into ThinkCycle.

… the different categories of challenges, comments, resources, etc are a bit confusing. However, with time, using the site definitely becomes easier.
“... too many layers and definitions that are not intuitive. Ultimately there is a simple way to do this, not executed here (though nowhere else either).”

“It was oddly organized. I didn’t know what ThinkSpaces were for a while.”

“The Filespace in particular has a strongly non-intuitive organizational structure, and it’s very difficult to correct posted mistakes. Even as a regular user, I often lose track of files.”

Batch File Uploading: 12% found it cumbersome and time consuming having to upload multiple files one at a time, which “restricted the ease of use for file transfers and open access”.

Information Clutter: 12% found the site “cluttered” with “too much information on one page”.

New Features to Improve Interaction on ThinkCycle

A. Improved Navigational Interface:
It is clear that changing or enhancing the existing navigation and organizational aspects on ThinkCycle would ease most of the difficulties encountered by users. Though the site interface could be refined, a complete reorganization of the site and database structure would be infeasible. However, a pop-up site-map that tracks users on the site and provides context-dependent help and glossary of terms could make navigation on a complex site more intuitive.

B. Asynchronous Content Updates:
24% of the respondents suggested the need for asynchronous content updates to the online site, particularly via email. Batch file uploading can be addressed by client-side FTP-like tools or email-based mechanisms that parse attachments and upload them to the site.

“Having it connected to email so I can input entries via email without having to load website.”

“If it were more integrated into my normal mail program somehow, if it had ways to create more content on-site.”

“Off-line use capabilities, for users with infrequent, unreliable, or unbearably slow connections to the internet. In particular:
+ the ability to batch-upload ThinkCycle content developed off-line. In other words, I generate a pile of reference hyperlinks, images, topics, notes, comments, etc, and email or ftp them to ThinkCycle in a compressed packet the next time I’m connected to the Internet.
+ similarly, the ability to download a text or plain HTML overview of current topics on the site. The email update announcements of new topics, etc go partway towards this goal. It would be nice if I could request an email summary of all the activity in a particular topic over some specified period of time.”

It also becomes clear that designers working on concept sketches find it cumbersome to scan and upload them regularly on the site. Hence, they suggested integrated scanning and sketching tools that can be used to scan/draw and upload several sketches to the site easily.

“Have a drawing tool (java) that connects to pen input for making sketches, and have an integrated scanning tool that immediately puts scans on the site.”

“Being able to sketch online would be great – not having to operate in another environment before porting to web.”

One solution is to develop an offline client application that asynchronously provides users with requested updates from the site and allows them to easily post text-based content (both without having to go online and browse the site). Later sketching and integrated scanning for batch uploads to the site can be added. Integrating such activities and parsing content via email is non-trivial. However, a Java-based client is being developed to test this approach.
Real-time Collaboration Tools:
It was expected that many participants would request real-time collaboration, however a significant number (35%) requested online chat integrated on the site. This suggests that participants view the design activity as a social process, with the need for spontaneous conversations with online peers supported by tools such as chat (in addition to email).

“When a team member is on-line I would like to chat with them. I use MSN with my team members in Montana and it helps to know when they are on-line, and give me instant access to them.”

Only three respondents suggested other real-time collaboration tools such as shared sketching, video-conferencing and shared file annotation. However, these were considered “interesting” options that may augment online interactions rather than a critical part of collaborative design.

“Ability to draw stuff on it - like a designers easel something like that would make it so more realistic esp. if communities from diverse places are communicating with each other.”

“Video conferencing would be an interesting collaboration feature. Perhaps having a video stream on a split window website allowing people to surf the site while talking about the project they are working on. This would be incredibly useful for showing someone your work while simultaneously getting feedback.”

“A way to work on the same file and track changes made by each user.”

Many off-the-shelf packages provide such functionality, however naturally integrating them into the design process and the user interface/database in an online site is far more challenging.

4.4 Key Themes and Recommendations

4.4.1 On Studio Courses for Sustainable Design
From responses to the studio design courses conducted over two consecutive years, it is clear that courses focusing on sustainable design through hands-on learning have a broad appeal among students, serve a valuable role in university curricula, and show concrete outcomes in terms of exposure, learning and working design projects. However, the success of the course requires not just well devised curricula and notable practitioners as guest speakers, but better preparation by instructors to develop well-posed design projects, more team/project mentoring, and greater effort to connect external organizations and domain experts with students throughout the design process. Opportunities for fieldwork before, during and after the course should be encouraged to make the design projects more relevant and meaningful to both students and stakeholders.

Though some students enjoyed an open-ended studio, others (typically undergrads) suggested added structure and deadlines to improve student involvement and project completion. Finally, most students agreed that the studio should be offered for credit to provide an additional incentive for them to seriously commit more time towards their design projects. However, course-grading schemes should be carefully devised to encourage collaboration, peer review and real-world assessment rather than emphasis on novel artifacts and competitive metrics.

Sustaining such studio courses in university settings requires: 1) strong commitment from university administration in recognizing the need and value for such courses to enhance real-world learning, 2) strong commitment from faculty in taking a lead on formally teaching novel studio courses or integrating socially-relevant design curricula into existing courses, 3) an important role for student instructors and domain experts mentoring teams during the design process, and 4) opening academic barriers to reach out to industry and field organizations to create mutually relevant partnerships towards real-world design projects.
4.4.2 On Collaborative Design Platforms

The survey indicates that participants find online collaboration tools useful and did indeed use ThinkCycle during the course. From usage patterns it seems clear that browsing and searching information was more prevalent than posting content. The web seems to be more useful as a medium for dissemination of information on sustainable design and resources, rather than primarily as a collaboration tool. Clearly participants do collaborate both face-to-face and using electronic modalities such as email and chat. However to encourage active online design collaboration, the affordances and usability of online tools must match their expectations with existing channels of communication.

Most respondents mentioned lack of time, being face-to-face, the overhead of posting content and lack of users monitoring their projects online as key reasons for not posting content frequently. Half the participants also found ThinkCycle somewhat complicated and time consuming to use, due to difficulties in navigation, structure and some interface issues related to file uploading. However, most managed to learn to use the system over time and adapt to the structure of the site.

The survey responses suggest four ways in which users viewed the online system: 1) a shared group space, 2) an evolving project repository, 3) a problem solvers area and 4) an open social space. These critical affordances (though often intersecting) must be supported in online collaborative design tool. In addition to an improved navigational interface, many users requested tools for asynchronous content updates (via email or ftp-like clients) and real-time chat. Overall responses suggest that users view design as a social process rather than simply one of archiving and exchanging data.

Navigation and interface issues can be gradually resolved, yet social/cultural factors seem to have a more critical influence. Among engineering students there is a lack of prior experience and predisposition towards the notion of online collaboration; much of their design work tends to be hands-on and face-to-face. Hence, such online tools are perceived as an additional commitment, rather than a natural part of the design process. There needs to be greater exposure to such tools including some training and examples of how it can be useful in the design process. In addition, online interaction and deliverables should be gradually introduced to students during the course, rather than expected from the start. Finally, having external organizations and domain experts (not co-located with the teams) actively reviewing the projects, serves as a more meaningful incentive to have teams place their evolving designs online and use such an approach.
### 4.4.3 Next Phase of Study: Open Issues for Inquiry

The online survey was unable to address many issues that were further explored using intensive interviews with several key participants from the course. The main themes of inquiry include:

- **A. Nature of Design Process:** Understanding the evolution of design projects including key design criteria and decisions, social interactions, and artifacts created. How did the teams research, document and negotiate design constraints and concepts? How was peer-review solicited and incorporated in the design? What influenced the design process the most, and what were key motivations behind critical design decisions? How did the team use ThinkCycle in the design process?

- **B. External Linkages:** In what manner did students interact with external organizations and domain experts throughout their design process? How did they seek out such linkages and maintain them through the course? How did these interactions influence their work and learning? What were incentives for external peers to get involved, and how did they benefit from the interaction?

- **C. Intellectual Property and Public Disclosure:** We need to examine individual experiences in prior design projects in terms of disclosure and patents. To what extent did team members disclose their designs publicly (in class or website)? What factors prevented them from greater disclosure (competition, maturity of ideas, overhead involved, or market potential)? To what extent did the design projects benefit from external input? Does the team plan to field-test, patent, license or disclose their ideas in the public domain? Do team-members wish to participate in open source projects in the future? Under what conditions?

In the next chapter we will consider these issues, but focus particularly on social perceptions and approaches towards intellectual property rights in collaborative design projects.