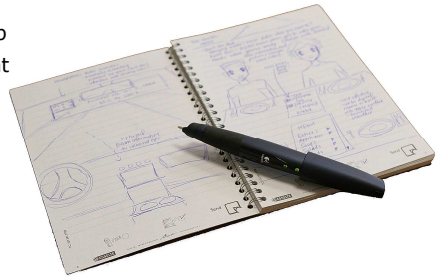
Technology for Design Education: A Case Study

Heidy Maldonado
Stanford University HCI Group
Stanford Center for Innovations in Learning, School of Education
Stanford, CA 94305 USA
heidym@cs.stanford.edu

Brian Lee
Stanford University HCI Group
Computer Science Department
Stanford, CA 94305 USA
balee@cs.stanford.edu

Scott Klemmer
Stanford University HCI Group
Computer Science Department
Stanford, CA 94305 USA
srk@cs.stanford.edu



CHI 2006, April 22–27, 2006, Montréal, Québec, Canada.
ACM 1-59593-298-4/06/0004.

Abstract
We present results of the first longitudinal study of physical and digital technology hybrids for design education. Through deployment in an introductory HCI class, we have instrumented and analyzed traditional design practices with newer technological components. In particular, we show that *hybrid Idea Logs* that maintain the *flexibility* of paper notebooks can successfully implement the *fluidity* needed between teammates in design projects, and between the digital and physical world. Our preliminary analysis of questionnaires, performance data, and student design notebooks support our hypothesis that this hybrid of technologies may effectively address the needs of this domain, and suggest that basic digital affordances such as export and sharing of design content can improve the educational experience.

Keywords
Design education, Idea Log, technology probe

ACM Classification Keywords
H.5.1: Multimedia Information Systems—*artificial, augmented, and virtual realities*. H.5.2: User Interfaces—*input devices and strategies; interaction styles; prototyping*. K.3.1: Computer Uses in Education.

Figure 2. The Idea Log. Sample pages from students' design notebooks.

Introduction

Two long-standing practices in art and design education are the Idea Log [8], where students keep track of all their design ideas (see Figure 2); and the studio critique, where students present their work-in-progress to instructors and the class as a whole (see Figure 1). More generally, project-based learning courses feature interplay between times of individual ideation and reflection, and times of group presentation, discussion, and brainstorming—both in and out of the classroom. Design education is also distinct from many other disciplines in that the content is primarily visual (see *e.g.*, [6] for a description of "design thinking").

The Idea Log, also known as a design notebook or research notebook, provides a space for individual ideation and documentation: students take class notes, record team meetings, and sketch and write down design observations and ideas. The studio critique provides a form of peer learning that is unique to the art and design disciplines. It is a forum for students to show their work to their classmates and for that work to be acknowledged. It offers an opportunity for students to comment on each others' work, to see common strands, and to offer suggestions and critique. Participating in this joint discussion with their peers and instructors on the myriad ways their peers have approached an identical assignment—their diverse perspectives on the design problem and the multiple paths to its solution—is also beneficial.

Technology for Design

Observations and our own experiences with design education lead us to assert that there is significant potential for further—and better—integration of technology into design activities. In particular, we note one emerging trend in design and design learning: the appearance of electronic media alongside physical media as a vital tool in education [7] and design process.

The Physical-Digital Divide

Currently, design students and practitioners use physical notebooks and walls for their expressive power, sketch-based interaction, and familiarity. The paper notebook remains the repository for ideas: it is an excellent medium for sketching, it is portable across varied contexts and scenarios, lightweight, and its "display" has infinite battery life. As Gershenfeld writes, "If the book had been invented after the laptop it would be hailed as a great breakthrough. It's not technophobic to prefer to read a book; it's entirely sensible. The future of computing is back in a book" [4]. Paper notebooks are also reliable, robust, and easy to browse. However, search and reorganization of content in a paper notebook is challenging a best. Sharing said content, of particular interest for the distributed teamwork that constitutes the core of design practice, is likewise difficult.

Figure 1. The studio critique, modernized. A student presents design ideas on an electronic wall in Wallenberg Hall.

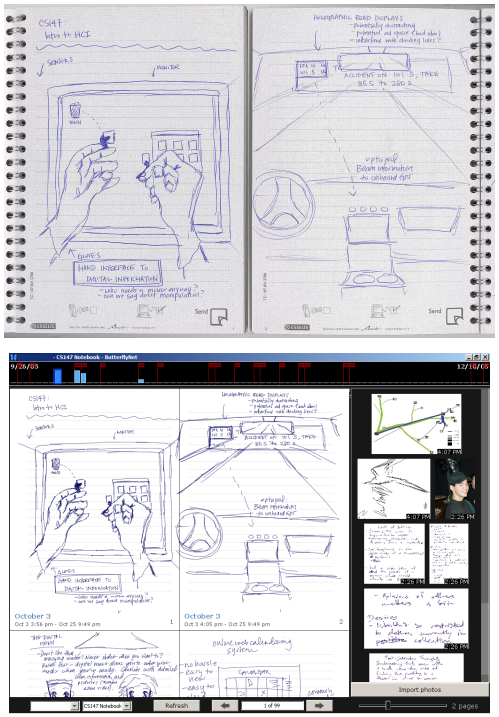


Figure 3. *Top*: Pages 1 and 2 from a student's Idea Log. *Bottom:* The same pages viewed in the ButterflyNet browser. Notebook pages are presented in the left-hand content panel, while related pictures and images are presented in the right-hand context panel. Above, a timeline shows class milestones along with a bar graph displaying the amount of notes collected on days throughout the quarter.

With the introduction of systems such as the Stanford iRoom [5], the studio critique has incorporated electronic technologies. Electronic media have begun to exist alongside physical media for individual ideation and documentation as well. Students now carry digital cameras with them, increasingly in the form of camera phones, keeping the full collection of photographs on their computer or on the web, and printing and pasting the most important photographs into their log book. Interactive prototypes and written documents are also created on the computer, based on sketches and notes in the log.

Traditionally, interactive systems have addressed the processing and manipulation of "structured" content: word processing, email, web browsing, etc. Learning technologies—from graphing calculators to electronic portfolios [2]—have generally followed this trend. Learning tools for the creative production of sketch-based content, though not ignored completely, has certainly been understudied. However, the two worlds still coexist apart, and the infrastructures for bridging this divide (scanning, typing and printing) are cumbersome and time consuming, at odds with the constraints and constant fluid iteration of the design process.

iDeas Learning Ecology

Seeking to merge the advantages of the physical world with those of the digital world we are developing a comprehensive system for design education, the *iDeas learning ecology*. Its objective is to fluidly integrate mobile devices and interactive workspaces into existing design and design education practices, enabling content to move more seamlessly between the physical world and the digital world and thus allowing users to take advantage of the affordances unique to each.

We are studying the use of digital pens and corresponding paper notebooks as Idea Logs through commercially available Anoto digital pens as our research prototype for the pen of the future. These pens have the ability to record the position, pressure, and timing of the strokes on paper. The iDeas learning ecology enhances these off-the-shelf functions with browsing, calendar, timeline, and export capabilities that allow the design groups to record, analyze, reflect and share their ideas, observations, and sketches. Drawing upon the experience of instructors and design students, and inspired by the ButterflyNet system [10], the learning ecology comprises three elements: the iDeas notebook, the iDeas blog, and the iDeas wall.

Design probe: undergraduate HCI course

This Fall, we launched a probe [3] of the role of technology in design education through the deployment of the iDeas learning ecology. The purpose of this first longitudinal study in design education was to better understand existing practices in design learning, and to study which kinds of hybrid approaches to interaction design for design education would be most successful.

Thirty-one participants were involved in our 10-week study (23 male, 8 female). Subjects were students enrolled in CS147 [9], the undergraduate introductory HCI design course at Stanford University, and represented a diverse background of ages, departments, majors, years in school, and ethnicities. We chose this

Figure 4. Design students work on group projects in collocated fashion using a variety of devices.

course because it is an introduction to interaction design projects and Idea Log, both critical parts of design apprenticeship. Students were grouped into teams of three or four students to pursue a quarter-long project, during which they designed, prototyped, evaluated, and refined an interactive system. Project topics were determined by each group; examples included accessing text-based voicemail on handhelds, clothing assistants, and bus route helpers, among others. The Idea Log recorded individual students' design work on the project and class in general, and were maintained throughout the quarter.

Eighteen students in one discussion section of the course were provided with Anoto digital pens, corresponding A5-size notebooks (148mm×210mm), and an initial version of our iDeas learning ecology for archiving and browsing their notes and images electronically. We sought to attain early feedback on the applicability of our hardware and software. The other 13 students, part of a second discussion section, were recruited as control subjects. These students did their coursework in the traditional fashion with other students in the class, using normal paper notebooks and pens for their Idea Logs.

Pre- and post-experience questionnaires were administered to all 31 participants, seeking to elucidate quantitative and qualitative assessments of their experience within the group project. In particular, students were asked about their group dynamics, design practices and note taking strategies in the course, as well as their assessments of the iDeas software and Anoto pen hardware. Performance data about their project was also collected, along with all of the students' Idea Logs and design notebooks.

Video data of the three student groups with the highest project ratings was collected throughout the quarter, as well as email and instant messaging communications from one of these groups. Though not yet processed, this data should help in determining some of the factors of successful groups negotiating the interweaving of social and cognitive factors involved in establishing a joint problem solving space, as highlighted by Barron [1]. Figure 4 shows images from several group meetings in which students make use of a number of diverse devices, including paper, pens, notebooks, whiteboards, laptops, and projectors. These images suggest that student designers are already using a variety of devices, both physical and digital, in the course of their design activities.

Study Results

The project grades across all sections for the class were evenly distributed; we did not find any undue bias or influence on performance due to introduction of the iDeas software or the Anoto pen. Grades in the experimental section and in all sections of the course were consistent with other years' distributions. Preliminary analysis of our data suggests several interesting directions to pursue as we refine the iDeas learning ecology to make it an integral part of design curricula.

Idea Logs

In the experimental section, students readily adopted the technology, filling on average 33 full pages each on their notebooks, with one student writing as many as 68 pages, despite the added weight and encumbrance of the batteries and technology in the pen. The form factor of the pen had us concerned that the students would prefer to turn in traditional Idea Logs rather than take notes and sketch with the Anoto digital pen we

Figure 5. Design students on a field trip recording observations and interviews in their Idea Logs with the Anoto pen. (January 2006)

provided. We were pleasantly surprised to observe that, in general, the students found the benefits provided by the iDeas system to outweigh the challenges of adoption.

In fact, because students could take and use their notebooks and pen however and whenever they desired, we found that they used the system for note-taking in other classes as well, from Italian to optics and physics. Students in our control section seem to have covered more pages in their log books than those in our experimental section (54 to 33 full pages on average), possibly due to the ease of writing with other implements than the Anoto pens. However, the performance of the students in the experimental section on the Idea Log, project, and overall course did not vary significantly from the experimental section. We found no correlation in our sample between the numbers of pages filled in their Idea Log and students' project performance or reported group dynamics.

Attitudinal Responses

Participants rated the iDeas system as significantly useful, easy to understand, and easy to learn (median 4, 5-point scale). Students preferred using our system to export and share their design content over traditional means of doing so such as copiers and scanners (median 6 in a 7-point scale). Several students commented that the ability to quickly and fluidly share notebook content (via exporting it to word processors or email applications) was valuable, and asked for more direct ways to do so. The iDeas browser's capacity to display multiple pages, visualize a timeline of when pages were created, and view pages within a calendar were also cited as useful.

Our fears about the form factor in the Anoto pen were corroborated by the students' perceptions, despite the heavy use the pens received in practice. More than half of the 18 subjects in the experimental section complained that the Anoto pen designed by Nokia was too large, making it both hard to hold and annoying to carry around on a regular basis. Several subjects commented that battery life was an issue as well.

While other studies of the Anoto pen (*e.g.*, [10]) have not noted form factor as a serious problem in user tests, it has proven to be a serious barrier to adoption among consumers. For purposes of our study, the Anoto pen is a research prototype. Though our prototype worked as well as traditional methods, we look forward to experimenting with future hardware that may provide a better experience for designers. With less cumbersome devices, we could extrapolate deeper performance differences across groups.

Current Steps

We are applying our findings to further iterations of the iDeas learning ecology. Seeking to develop tools that will enhance the design experience for student groups, we have incorporated new capabilities for collaboration and sharing in the current iDeas deployment. This quarter will see 50 students in CS247, the HCI design studio course at Stanford, using the system exclusively. Following last quarter's probe, more novel digital affordances have been built into the browser, primarily support for group-based sharing and annotation. As part of our long term goal of bridging the gap between the physical and digital worlds for designers, we plan to integrate additional design artifacts into the learning ecology, such as mobile devices and augmented whiteboards.

Conclusion

We have presented findings and discussed implications of a longitudinal probe of technology for design education. The field of design education presents several challenges particular to design: its emphasis on visual content, groupwork, fieldwork, creativity, and spontaneity often means that traditional technological solutions do not apply. We have found that fluid combinations of physical and digital technologies appear to effectively address the needs of the domain, introducing useful affordances, such as export and sharing, without imposing undue costs of adoption. This probe is a step forward in helping us understand the requirements and tradeoffs of such systems. As we continue to develop and deploy the iDeas learning technologies, we look forward to contributing to the evolving culture and practices of design education.

Acknowledgements

We thank Terry Winograd, Roy Pea, and Lars Erik Holmquist for their insightful discussions, and the teaching staff of CS147 for their invaluable assistance throughout the quarter. We are also grateful for the support of Nokia and the Wallenberg Global Learning Network. Finally, we thank the study participants for their forbearance and cooperation.

The iDeas software is open source, and is available at http://hci.stanford.edu/research/ideas.

References

1 Barron, B. When smart groups fail. *Journal of the Learning Sciences* **12**(3). pp. 307-59, 2003.

2 Cambridge, B. L., ed. *Electronic Portfolios: Emerging Practices In Student, Faculty, And Institutional Learning*. ed. 240 pp., 2001.

3 Gaver, B., T. Dunne, and E. Pacenti. Cultural Probes. *interactions* **6**(1). pp. 21-29, 1999.

4 Gershenfeld, N., Bits and Books, in *When Things Start to Think*. Henry Holt & Co: New York. pp. 13-25, 1999.

5 Johanson, B., G. Hutchins, T. Winograd, and M. Stone. PointRight: Experience with Flexible Input Redirection in Interactive Workspaces. UIST: ACM Symposium on User Interface Software and Technology *CHI Letters* **4**(2): ACM Press. pp. 227–34, 2002.

6 Lawson, B., *How Designers Think: The Design Process Demystified*. 3rd ed: Architectural Press. 352 pp. 1997.

7 Pea, R. D., & Maldonado, Heidy, ed. *WILD for learning: Interacting through new computing devices anytime, anywhere*. ed. The Cambridge Handbook of the Learning Sciences. K. Sawyer. Cambridge University Press: New York, 2005.

8 Verplank, B. and S. Kim. Graphic invention for user interfaces: an experimental course in user interface design, *ACM SIGCHI Bulletin*, vol. 18(3): pp. 50–66, 1986.

9 Winograd, T., *CS147: Introduction to Human-Computer Interaction*, 2005. Stanford, CA. http://cs147.stanford.edu

10 Yeh, R. B., *et al.* ButterflyNet: A Mobile Capture and Access System for Field Biology Research. In Proceedings of *CHI: ACM Conference on Human Factors in Computing Systems*. Montréal, Québec, Canada, 2006.