Designing Shape-shifting Collaborative Laboratory Spaces to Facilitate Game-Design Education

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ABSTRACT
In this paper, we describe a novel approach to computer laboratory design for multidisciplinary education, including game design. The Cornell Library Collaborative Learning Computer Laboratory (CL3) is a shape-shifting workspace in which students and instructors can move semi-circular, dual-workspace computer tables to fit a wide-variety of group needs and sizes. We demonstrate that this concept facilitates game-design and development education. Early studies indicate that CL3 does indeed work, though the concept needs a few refinements with respect to training and demonstration.

Categories and Subject Descriptors
D.2.9 [**Software Engineering**]: Management – *teams*.

K.3.1 [**Computers and Education**]: Computer Uses in Education – *collaborative learning*.

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *ergonomics*, *evaluation–methodology*, *interaction styles*.

H.5.4 [**Information Interfaces and Presentation**]: Group and Organization Interfaces – *collaborative computing*, *computer-supported cooperative work evaluation–methodology*.

General Terms
Management, Design, Experimentation, Human Factors.

Keywords
Collaborative Learning, Computer Laboratories, Game Design, Multidisciplinary, Education.

1. INTRODUCTION
Game-design programs involve multidisciplinary work, often involving artists, writers, musicians, engineers, and so forth. However, typical computer laboratories, especially those for traditional face-front instruction and course needs, do not serve the wide range of game-oriented team work. When the Game Design Initiative at Cornell University (GDIAC, [1]) began in 2001, our own labs were limited to individual workspaces. As the multidisciplinary component grew, GDIAC realized the need for flexible, collaborative space. By merging with the Cornell University Library's *CreationStation* multimedia development facility [2], a cross-departmental team (Computer Science, University Library, and Academic Technologies) jointly developed the Cornell Library Collaborative Learning Computer Laboratory (CL3). CL3 opened in August, 2004 [3].

CL3 currently hosts GDIAC's core game-design courses, academic excellence workshops for introductory programming, and the new CreationStation laboratory. The facility can fit upwards of 30 students and has supported approximately 10K users each year in the past two years of operation. In this report, we first explain the background components that drove CL3's design. Next, we highlight elements of the implementation that can assist others in building similar collaborative space. Finally, we summarize the results of the current analysis and propose future work.

2. Background

2.1 Collaborative and Cooperative Learning
Collaboration and cooperation have become essential elements of modern educational pedagogy [4-6]. The CL3 project did not seek to justify the importance of teamwork, but instead, to determine *how* to facilitate collaboration with hardware and software. To explain this facilitation, we provide the following definitions:

- *Collaborative learning*: general team-based education.
- *Cooperative learning*: a specific form of collaborative learning that requires team interdependence, different skill sets, final product, and individual accountability.

We describe CL3 as *collaborative* because of the availability for public use. We describe how Cornell's game courses use cooperation in Section 2.3.

2.2 Collaborative Programming
When CL3 was first conceived, the original model addressed the need for collaborative programming space. Cornell University's College of Engineering introductory courses often provide *academic excellence workshops*, which are pass/fail classes in which students work collaboratively on extra course material [7]. For introductory programming, the insufficiency of typical face-front computer labs drove the original plans for CL3. A common model involves *pair programming*, in which a pilot and co-pilot program as a pair, which has shown excellent results in education and practice [8]. Manufacturers have even begun to provide pair programming computer desks [9], and various programs have researched how computer desks can facilitate collaboration [10-12].

2.3 Game Design and Development Education

Game design and development education has flourished in the past few years, leading towards a call for an understanding of best practices [13]. Although pedagogy and content still vary (notwithstanding the wide range of courses and program names), one common aspect is the need for multidisciplinary teamwork. Although game design is an interdisciplinary field [14], students from music, art, writing, engineering, and more work together to produce original works. This collaboration drives tremendous interest in such education, which offers excellent team-skill development, appealing to many students.

As noted in Section 2.1, working on a game often involves cooperation. At Cornell, groups receive individual and group grades, whereby the individuals also rate themselves. This need for close collaboration and multidisciplinary work necessitates a collaborative learning space.

2.4 Learning Spaces and Location

One fundamental aspect of CL3 is the location, an issue perhaps often not addressed. By situating CL3 in a university library, we provide "neutral ground." Whereas not all schools may have this extreme separation, but the computer science and art departments are at literal ends of the campus. Because game design requires joint effort and mutual respect, identifying central and neutral areas is key to facilitating collaboration.

3. LABORATORY DESIGN

This section explains how CL3 addresses the fundamental issues and ideas expressed in Section 2.

3.1 Table Design

CL3's core design starts with a pair-programming computer desk, two of which are illustrated in Figure 1:

- Curved, one eighth-circle to allow for semi-circles in a classroom arrangement.
- Seating on the inside curve to use classroom space more efficiently. Note that an inside curve helps to alleviate lines of sight that aim away from partners.
- Table rollers—each table forms a moveable unit to create larger collaboration groups, perhaps even an entire class.

To determine the dimensions shown in Figure 1, we worked with Cornell's laboratory guidelines. We also developed a full-scale mockup to test user-responses to the environment with informal surveys.

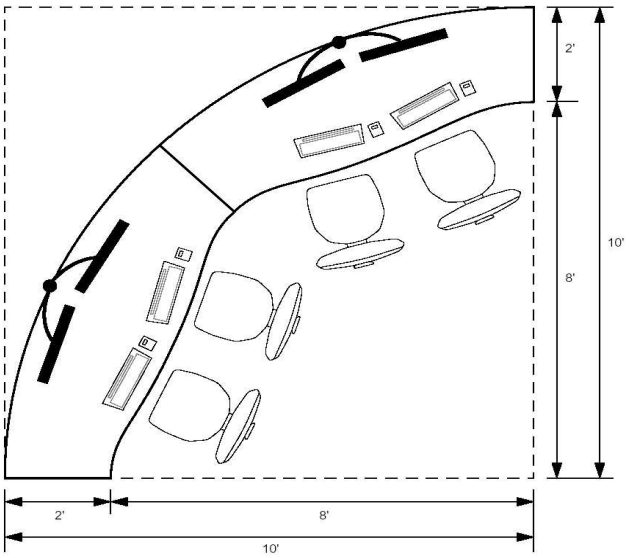

Figure 1. Two of CL3's pair programming desks.

3.2 Workstations and Input Devices

A commonly asked question is the choice against laptops. For example, Stanford's "Teamspace" lab [12] uses a shared large-screen monitor with individual laptop inputs. However, given the interest in building flexible space, portable large-screen monitors proved too costly.

The fundamental design seeks to provide a space in which neither the pilot nor co-pilot at a workstation would have an advantage, driving the project. So, CL3 workstations are dual input: two mice and two keyboards. Both users at a single workstation must negotiate for control. Given the use of Windows XP for maximum software flexibility for public use, support for simultaneous dual-cursors/pointers was limited. In Section 5, we will address this notion further, due to upcoming collaboration software releases.

To allow for rapid table movement and shape-shifting, each table has a UPS unit that provides "plug-and-play" capability to each workstation. Albeit not a standard use of a UPS, our units have lasted over two years.

3.3 Networking

The original conception for CL3 had a completely shared network, where any group could send their project to any other machine, real-time. Due to the demands of games, the software at the time did not suffice. For schools with limited budgets our solution provided a suitable alternative. CL3's computers all connect to a common network, both wired and wireless. So, students can share files, moving files to machines (including the instructor's). Technologically, this option required relatively little extra cost and still afforded the inter- and intra-group collaboration that we sought.

3.4 Instructors and Facilitators

When designing CL3, we accounted for multiple instructors, especially with the needs for game-design education. Co-instructors, peer facilitators, and teaching assistants all need to weave from group to group. Two catch phrases in education nicely summarize teaching styles: "chalk-and-talk" and "guide-by-the-side." As students develop their game, allowing group time is often more productive than the traditional lecture style. Thus, a classroom space that allows for guided group time greatly assists project development. In CL3, we provide two locations for an instructor podium (shown in Figure 2), portable wireless keyboard, and operator workstation, all linked together. Not only

do co-instructors have an ability to demonstrate and communicate examples, but student groups can split duties during presentations (e.g., play a prototype and give PowerPoint slides).

Figure 2. Portable instructor podium

3.5 Layouts

For mobility and flexibility, we endeavored to place as many power outlets in the raised floor as possible. To avoid breaking the budget with a completely electrified grid, we used cutouts of the tables to determine a large variety of table configurations for the given space. Figure 3 shows three configurations for the room. Given a choice of space, we would have preferred a square room, though the rectangular space sufficed.

The configurations in Figure 3 demonstrate three kinds of collaboration for game design groups. From top to bottom,

- Parallel order: provide an approximate traditional environment for lecturing.
- Distinct order: provide semi-private workspace.
- Shared order: provide larger-scale group space or inter-group review areas.

In each of these cases, the configurations facilitate common activities for game-design groups. Moreover, allowing the students to shift table configurations "on-the-fly" provides a degree of fun to the class time, in keeping with the focus on games.

3.6 Resources

One key aspect of the design is the involvement of an independent organization outside of game creation. For Cornell, the University Library provides several services that match the needs of game creation:

- Storage of digital-arts tools (e.g., musical keyboards, recording equipment, drawing tools).
- Storage of games, systems, and accessories.
- Staffing and oversight.

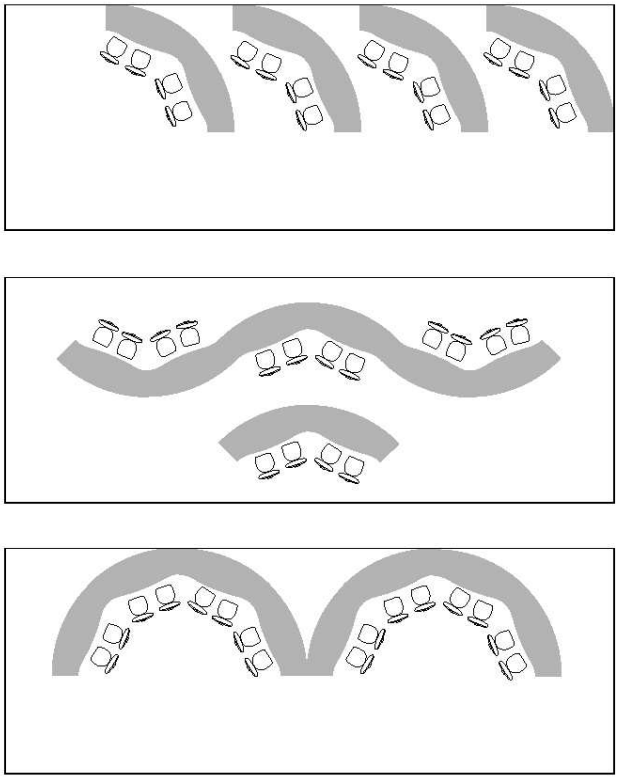

Figure 3. Example table configurations (to scale)

Besides finding space, designing the tables, and finding resources, accounting for constant monitoring was crucial. Allowing students to move tables breaks common conceptions. An organization set up for monitoring, staffing, and loaning—a library—provides an ideal partner for game creation [3].

4. EVALUATIONS

From Fall 2005—Spring 2006, two Cornell courses involved in human-computer interaction and ergonomics offered to use CL3 as an example to study. We present the general findings of both studies in this section [15].

4.1 Human-Computer Interaction

In Fall 2005, the first course project sought to investigate whether or not CL3 facilitates collaboration and suggest improvements to the design. The study involved a questionnaire given during class times. About 55% of the 38 responses came from the introductory game-design students. Key findings that the evaluation reported include the following for the total number of respondents:

- 30% moved tables.
- 46% struggled over the mouse.
- 39% struggled over the keyboard.

In terms of moving the tables, common comments from students included the following:

- "no need" (as the instructors or other students have already picked a suitable arrangement).
- Being unaware of mobility (lack of instruction or demonstration of CL3 tables).
- Fear of breaking something

The report provides further details. Given that 74% reported preferring collaboration, and 83% reported satisfaction, the

surveyed students seemed genuinely interested in a collaborative facility. The survey team concluded that while collaboration does indeed occur in CL3, there are weaknesses that need addressing, based on the above findings. One key issue that the team related is the need for communication concerning CL3's mobility and assuaging fears of damaging the equipment.

4.2 Ergonomics

In Spring 2006, an entire advanced course in ergonomics used CL3 as an experimental project to test. This study expanded upon the first team's work, delving into the specifics of the table design, instruction on lab use, measurement of collaboration, and constructive suggestions.

The team surveyed 55 CL3 users and gathered the following data:

- 43% move the tables, with about half of the responses indicating that table movement helps to facilitate collaboration.
- 37% of non-movers were unaware of table mobility.

The survey team points out another interesting notion in terms of conflicting understanding of collaboration during public hours. Outside of "trained" game-design students, other students would sometimes consider the space strictly as quiet, despite CL3's name. Although the library offers neutral ground, it carries this other preconception.

Whereas this survey also concluded that CL3 does facilitate collaboration, they did offer several constructive suggestions to improve the concept:

- Educate users about posture to improve seating and use of input devices.
- Educate users about table adjustments and mobility, especially to improve collaboration. For example, visual/hardware "cues," such as handles would help.

5. FUTURE WORK

In both studies, the surveys reached a small group of students. Our next step is performing a large-scale study with questions focused on table movement and collaboration. In the interim, we intend to focus on educational material (e.g., signs, login screens, lab operator training, instructor training, and workshops) to help demonstrate CL3's capabilities. The subsequent results should prove interesting to see if our proposed efforts will help to break down preconceptions on lab use.

6. ACKNOWLEDGEMENTS

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