Scaffolding Cooperative Multi-Device Activities in an Informal Learning Environment

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Abstract

Informal learning environments, e.g. children's science museums, provide special challenges for educational software design: the software must (1) be immediately accessible, (2) convey educational content within short episodes of use, and (3) should allow multiple users to participate at the same time. While mobile technology allows for multiple simultaneous users, significant scaffolding is required to allow groups to walk up and productively use it. Using a design experiment approach, my research focuses on the design and evaluation of *distributed* scaffolds that enable informal learners to use mobile technology effectively.

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Multi-user interfaces, multi-device interfaces, co-located cooperation, distributed scaffolding, informal learning, complex systems, microworlds, simulations

ACM Classification Keywords

H5.3. Information interfaces and presentation (e.g., HCI): Group and Organization Interfaces --- Collaborative computing, Synchronous interaction; *H5.3. Information interfaces and presentation (e.g., HCI): User Interfaces* ---Evaluation/methodology*; K3.1. Computers and Education: Computer Uses in Education --- Collaborative learning*. I6.8. Simulation and Modeling: Types of Simulation --- *Gaming*, *Visual*; C2.4. Computer-Communications Networks: Distributed Systems --- *Distributed Applications.*

Introduction

Educational Software in Science Museums

Unlike learning in traditional classrooms, learning in science museums is rarely a solo activity: the vast majority of visitors attend in groups. An alternative to kiosk-based educational software exhibits (which have form factors that limit input to one person and viewing to a few) is to employ multiple wirelessly connected devices to allow all members of a visitor's party to simultaneously participate in a shared educational software activity.

Accommodating group use is not the only design challenge, however. Visitors typically spend only a minute or so at an exhibit [2], so the software must be able to be immediately usable (so visitors won't walk away in frustration) and must be able to communicate educational content within a small time window. Ensuring that these goals are met when there are multiple users requires sophisticated guidance, known in educational parlance as *scaffolding*.

Scaffolding for Multi-Device Educational Software

This work builds on prior experiments I have conducted with the Multi-User Simulation with Handheld Integration (MUSHI) framework [5, 6]. MUSHI is a multi-device framework designed to allow small groups of users to experiment together within a shared educational simulation (i.e. a *microworld*). I am now adding a distributed scaffolding element to make a MUSHI-based exhibit practical for use in a children's science museum. Scaffolding, in a software context, is the presence of passive or active user interface elements that aid users in accomplishing more (e.g. exploring a simulation more purposefully) than they would be able to without such guidance, and is a core technique in Learner Centered Design (LCD) [8].

The scaffolding I propose to create is unique in that it (1) is distributed across multiple devices intended to be used in the same place (i.e. *co-located*) at the same time (i.e. *synchronously*), and (2) aids multiple users to coordinate their actions within a shared environment (e.g. a shared simulation). By *coordinate* I mean that the system guides users towards actions that are mutually beneficial, and away from actions that contradict those of other users.

I will first provide a scenario to illustrate the use of a scaffolded MUSHI exhibit in a children's science museum, followed by a brief overview of prior work, my methodology, and the contributions of this research.

Use Scenario

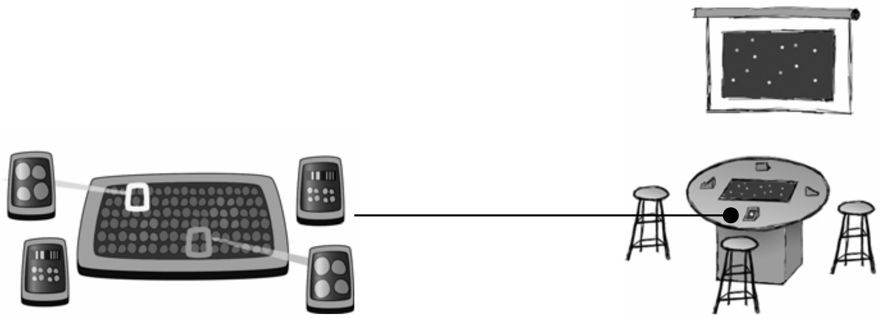
In this scenario, a father and his two children, aged 8 and 12, use handheld devices to cooperatively fight cancer in simulated human tissue (see Figure 1). I will list several actions performed in this context, to highlight the scaffolding design goals.

Challenge: Immediate Engagement

The younger child can press buttons right away, irradiating the cells displayed on his handheld, which depicts a "zoomed-in" view of a small region of the simulation (see callout, Figure 1). The father and older child, cued by animation and sound effects, can see cells die by looking at the shared monitor or the projection. These immediate effects are a form of *passive accountability scaffolding* (see Table 1).

Challenge: Short Episodes

The older child picks up a handheld and the scaffolding system, detecting a new player, delivers a message to her device that suggests how she can help by "surgically excising" tumors with her stylus. By cooperating, the children will be able to complete the episode much more quickly. This combination of *positively interdependent* role assignment (i.e. the sister's role has a different, and complementary, set of actions) and *targeted messaging* is an example of *active coordination scaffolding* (see Table 1).



The four handheld devices wirelessly communicate with the server embedded in the base of the table, and display "zoomed-in" views of regions of the simulation, which is displayed in its entirety on the shared monitor and replicated on the projected screen.

figure 1. Sketch of the MUSHI exhibit. A monitor is inset in the tabletop, with four handheld computers resting in cradles. A computer embedded in the base runs the simulation, displayed on both the monitor and on the overhead projector.

Challenge: Supporting Multiple Users

The children can inspect different regions of the shared simulation by "steering" their "zoomed-in" views. This alignment of form factor with a "shared but individual" use paradigm allows multiple users to meaningfully work within the same microworld (see Table 1). The use of individual devices also allows users to select different difficulty levels. The father can select the "Thoughtful" play style (as opposed to the "Right now!" option his children selected) on a third handheld. He will be asked to engage in a more complicated task, like designing proteins that will attach to cancer cells.

Prior Work

My work draws from many areas, and so here I cite only a few examples that explore similar content. Both I and other researchers have explored, in a *classroom* setting, distributing synchronous, co-located cooperative simulations across multiple devices [5, 6, 7]. I draw on such work, in addition to work done with individual handhelds in museum settings [e.g. 3]. Lessons learned with the scaffolding of *remote* synchronous cooperation [4 has a review] also have some bearing on designs for my *co-located* scaffolds.

Design Goal	Scaffolding Design Strategy	Assessment Measures
Immediate engagement	Make user actions immediately apparent on both handheld & shared simulation displays (i.e. passive *accountability* scaffolding)	Use logs to measure: • initial activity levels • proportion of visitors who leave quickly Use interviews & surveys to gain affective feedback on usability
Short episodes	Positively interdependent roles with dynamic, state-dependent targeted messaging (i.e. active *coordination* scaffolding)	Use logs to measure: • number of complementary vs. contradictory actions • responses to active scaffold prompts • time to completion of episodes • number of completed episodes Use pre-& post-tests
Multiple-user support	Multiple devices as interfaces to single shared simulation (i.e. form-factor *alignment*) Roles of different difficulty	Use logs to measure: • average number of users per episode • user activity patterns Use interviews & surveys to gain affective feedback on group usability Videotaped interactions

table 1. Overview of design goals, organized by target area.

Design Assessment Methodology

The design challenges motivating this work are the need to create an educational software exhibit which visitors (1) can engage with immediately, (2) can learn from within short episodes, and (3) can productively use together. My initial design employs several strategies to accomplish these aims (see Table 1). I am following the *in situ* Design Experiment methodology originally developed for engineering *classroom* learning environments [1]. This methodology acknowledges that the many facets of a learning environment often combine synergistically, and thus need to be evaluated in conjunction with one another. It also stresses the combined use of quantitative and qualitative measures, to "tune" the design of the learning environment.

The assessments I plan to use include software logs of visitor behavior, pre-and post-tests of content knowledge, surveys and interviews to obtain affective feedback, and videotapes (with dialogue analysis) to study visitor interactions (see Table 1). All visitor uses will be logged, but for tractability only a selection of users will take part in the remainder of measures.

Contributions of Work

In recursively attempting to attain the design goals, a result of this research is a set of empirically-validated *design guidelines,* which can help others design scaffolding for the cooperative use of synchronous, co-located multi-device systems. Such guidelines are relevant to both the Computer-Supported Collaborative Learning (CSCL) and the Computer-Supported Collaborative Work (CSCW) fields, and become more and more pertinent as the usage of personal devices (e.g. handheld computers, cellular phones) becomes more prevalent. Moreover, the experiments used to derive these guidelines will provide empirical evidence concerning visitor behavior and learning in an informal context that may be of interest to the museological and learning science communities.

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Citations

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