Distributed Constructionism

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Abstract: This paper introduces the concept of *distributed constructionism*, building on previous research on constructionism and on distributed cognition. It focuses particularly on the use of computer networks to support students working together on design and construction activities, and it argues that these types of activities are particularly effective in supporting the development of knowledge-building communities. The paper describes three main categories of distributed constructionist activities: discussing constructions, sharing constructions, and collaborating on constructions. In each category, it describes ongoing research projects at the MIT Media Lab and discusses how these projects support new ways of thinking and learning.

Introduction

At a recent educational-research conference, researchers were debating various approaches for using computer networks in education. One group of researchers talked excitedly about new ways of delivering instruction to students. They explained how lectures by expert scientists could be beamed down to thousands of schools. They imagined the day when personal workstations will present problems to students, monitor student progress on the problems, and automatically download video segments from network servers at appropriate times during the instruction.

A second group of researchers presented a different vision for computer networks in education. They dismissed the idea of delivering information to students across the network. They wanted to turn the tables, putting students in control of the information. They talked about new tools that allow students to search through thousands of servers on the network, locating information that they are interested in.

These two approaches are very different from one another. In one case, information is delivered to students according to some instruction plan; in the other case, students search for the information they need, when they need it. But the two approaches share a common feature: they both focus on *information*. Indeed, amidst all the talk about the "information superhighway" and "information society," the idea of information is often at the center of discussions about computer networks in education.

This paper describes a third vision of computer networks, strikingly different from the first two. This vision puts *construction* (not information) at the center of the analysis. It views computer networks not as a channel for information distribution, but primarily as a new medium for construction, providing new ways for students to learn through construction activities by embedding the activities within a community.

The paper introduces a theoretical underpinning for this approach, known as *distributed constructionism*, then describes a set of research projects at the MIT Media Laboratory designed to explore the educational possibilities for using computer networks in support of construction activities. The paper does not go into great depth on any one project or activity; rather, it aims to provide a framework for thinking about collaborative construction activities and the role of computer networks in supporting those activities. It highlights several new network-based environments that our research group is developing to enable pre-college students to collaborate on the construction of dynamic artifacts (such as animations and simulations).

Distributed Constructionism

Constructionism [Papert, 1991] is both a theory of learning and a strategy for education. Constructionism is based on two types of "construction." First, it asserts that learning is an active process, in which people actively construct knowledge from their experiences in the world. People don't *get* ideas; they *make* them. (This idea is based on the *constructivist* theories of Jean Piaget.) To this, constructionism adds the idea that people construct new knowledge with particular effectiveness when they are engaged in constructing personally-meaningful products. They might be constructing sand castles, poems, LEGO machines [Resnick, 1993], or computer programs [Harel, 1991; Kafai, 1995]. What's important is that they are actively engaged in creating something that is meaningful to themselves or to others around them.

Distributed constructionism extends constructionist theory, focusing specifically on situations in which more than one person is involved in the design and construction activities. It draws on recent research in "distributed cognition" [Salomon, 1994], recognizing that cognition and intelligence are not properties of an individual person but rather arise from interactions of a person with the surrounding environment (including other people and artifacts). Recent research projects have attempted to use computer networks to facilitate the development of "knowledge-building communities" [Scardamalia & Bereiter, 1991], in which groups of people collectively construct and extend knowledge. In many of these projects, students share ideas, theories, and experimental results with one another. Distributed constructionism asserts that a particularly effective way for knowledge-building communities to form and grow is through collaborative activities that involve not just the exchange of information but the design and construction of meaningful artifacts.

Computer networks can be used to support distributed construction activities in several different ways. The rest of this paper is organized around three major categories of distributed construction activities (with examples of projects from our research group in each category):

- Discussing Constructions
- Sharing Constructions
- Collaborating on Constructions

Discussing Constructions

Perhaps the most basic constructionist use of computer networks is as a forum for discussing construction activities. By using electronic mail, newsgroups, and bulletin boards, students can exchange ideas, tips, and strategies about their design and construction activities.

For example, Michele Evard has examined how a computer network allowed elementary-school students to share ideas with one another while they were engaged in a project designing their own video games [Evard, 1996]. The students exchanged questions and answers through a Usenet-style newsgroup. By the end of the project, the students produced much more sophisticated video games than students in previous years (who did not have access to network discussion groups). The students found answers to technical problems more quickly, and good design ideas spread through the class more rapidly. Interestingly, Evard found that the students used the video game newsgroups much more frequently than they used other online newsgroups that were not directly associated with ongoing construction activities.

Sharing Constructions

Beyond simply discussing constructions, students can use computer networks to share certain types of constructions with one another. In that way, students can try out one another's constructions, and perhaps copy and reuse parts of each other's constructions.

On the World Wide Web, students can create pages for others to see. But the Web is very limited in the types of constructions that it can support. Currently, it is used primarily for displaying "passive" data forms such as text, images, and videos. Students can not easily post animations, simulations, and other process-oriented artifacts that they construct.

Brian Silverman and I developed the LogoWeb to enable students to share dynamic artifacts with one another. To the student, the LogoWeb software looks identical to MicroWorlds, the most common commercial version of Logo. Students can use the LogoWeb software to create animated stories and simulations, just as they would in MicroWorlds. But instead of saving their projects on a local hard disk, students can save their projects on the LogoWeb (a network totally separate from the World Wide Web). Once a project is saved on the LogoWeb, anyone else with an Internet connection and a copy of the LogoWeb software can access the students' creations.

The LogoWeb hides all of the messy inner workings of the Internet (such as URLs and directory hierarchies) from the students. Students need to learn only two new commands: `savelink` (to save a project on the LogoWeb) and `linkto` (to access a project on the LogoWeb). Students use multiple-word file names to create an implicit directory structure (for example, using the name of their school as the first word in the file name).

In an initial trial, two elementary-school classrooms (one in California and one in New York) used the LogoWeb to post copies of video games that they had written in Logo. Students at each site were able to try out one another's games, look at the underlying code, and copy segments that they found useful for their own projects. In the future, the LogoWeb could serve as an ever-growing museum of Logo projects, where students go to get ideas for new projects and to exchange projects with friends.

Of course, it would be much better if these types of projects could be shared on the World Wide Web itself, rather than on the separate LogoWeb network with its own software. With the new Java programming language, people can now create LogoWeb-like dynamic projects on the World Wide Web. But there is a problem: Java is designed for expert programmers, not for pre-college students. Java will no doubt lead to a proliferation of dynamic Web pages, but most students will be only users of those pages, not designers.

In an effort to blur this boundary between designers and users, our research group is now developing a new environment that we call Cocoa—a type of "Java for kids." As with LogoWeb, students can create Logo-like animations and simulations, but they can place them directly on the World Wide Web. A major challenge is to facilitate the sharing of objects in Cocoa. Our goal is to make it easy for students to copy and reuse parts of each other's projects—for example, copying a "flying bird" from one project and inserting it into a different project. We are developing libraries of "clip behaviors," analogous to clip art. Students can clip a behavior from one page and insert it directly into another object.

Collaborating on Constructions

Computer networks can support a more fundamental change when they enable students not only to share ideas with one another, but to collaborate directly, in real time, on design and construction projects.

MUDs provide one approach for collaborative construction on the Internet [Curtis, 1992; Bruckman & Resnick, 1995]. MUDs are text-based virtual worlds in which participants literally construct the world in which they live, writing programs to define the behaviors of objects in the online world. MUDs began as multi-player game environments, but they have evolved into more general-purpose meeting places on the Internet, where people gather to enjoy one another's virtual company and to work together to extend the virtual world. For example, you can decide to be a purple bird and build yourself a nest, or you can become a munchkin and join others in building a replica of Oz.

MUDs explicitly combine construction and community. When people build new objects and places on a MUD, there are always other people around to act as users, consultants, advisers, and critics. As part of her research on the MediaMOO project, Amy Bruckman conducted a study of adults who learned to program on a MUD [Bruckman, 1994a]. She found that people learned to program more easily in MUD environments (than in traditional single-user settings). The reasons: programming became more authentic and motivating since there was an "audience" for the artifacts that they created; other members of the community provided technical help, emotional support, and feedback; the MUD world was full of example objects, providing a sense of what was possible, a source of ideas, and collection of reusable parts. More recently, Bruckman created a new MUD called MOOSE Crossing, designed explicitly as a learning environment for children [Bruckman, 1994b]. MOOSE Crossing includes a new programming language called MOOSE, designed to make it much easier for nonexpert programmers to join in the construction of the virtual world.

Computer networks also make possible new forms of modeling activities, in which students collaboratively construct models and simulations—and, in some cases, participate in the simulations that they construct. Greg Kimberly developed an environment called MarketPlace that enables students to participate in economic simulations over the Internet, playing the roles of buyers and sellers in a virtual marketplace [Kimberly, 1995]. MarketPlace includes online discussion facilities, designed to support not only economic deal-making among participants but also reflection and analysis of the economic patterns that arise from the interactions. Kimberly found that participants gained insights into core economic ideas such as supply and demand, economies of scale, and externalities.

Our research group is currently developing a more general-purpose modeling environment for the Internet, called the Network Clubhouse. The decentralized nature of the Internet makes it particularly well suited for modeling and exploring the workings of decentralized systems. People encounter many decentralized systems in their everyday lives (such as ant colonies, traffic jams, and market economies), but they generally have great difficulty understanding the workings of such systems, often assuming centralized control where none exists [Resnick, 1994]. Research has shown that modeling activities can help people develop better intuitions about decentralized systems. The Network Clubhouse is based on the belief that collaborative modeling activities will provide a new avenue for people to move beyond the "centralized mindset." For example, students can use the Network Clubhouse to collaboratively create an ocean ecosystem on the Internet, with each student programming the behavior of an "artificial fish"—then discussing with one another the systems-level phenomena that arise from the interactions. It is expected that students, through these activities, will be able to develop an understanding certain scientific phenomena (such as feedback, homeostasis, and self-organization) that are usually studied only at the university level, using advanced mathematical techniques.

With this type of activity, the Internet can support changes not only in the process of learning (bringing students together into collaborative projects) but also in the content of what is learned (providing a natural infrastructure for modeling and exploring decentralized phenomena). Too often, educational innovations focus only on *how* students learn, without enough attention to *what* students learn. Many of the representations and activities used in today's schools were developed in the context of (and are most appropriate for) pencil-and-paper technology. New media (such as the Network Clubhouse) make possible new representations and formulations of scientific knowledge—making that knowledge accessible to more people (and at younger ages) than previously possible.

The Internet as Rorschach

The Internet acts as a type of Rorschach test for educational philosophy. When some people look at the Internet, they see it as a new way to deliver instruction. When other people look at it, they see a huge database for students to explore. When I look at the Internet, I see a new medium for construction, a new opportunity for students to discuss, share, and collaborate on constructions.

Most of the projects described in this paper are still in their infancy. They lay a foundation for the study of distributed constructionism, bringing together ideas of construction and community. But much work needs to be done to more fully explore the ways in which construction and community can influence and enrich each other.

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Acknowledgments

Many members of the Epistemology and Learning Group contributed to the design and implementation of the projects described in this paper. Brian Silverman and Andy Begel have been responsible the technical underpinnings for several of the projects (LogoWeb, Cocoa, and the Network Clubhouse). Discussions with Alex Repenning have helpful in developing ideas about distributed constructionism. This research has been supported with funding from the LEGO Group and the National Science Foundation (grant 9358519-RED).