Pearls of Wisdom:
Learning in Distributed Constructionist Cooperatives

Robbin Chapman
MIT Media Laboratory
Cambridge, MA 02139
RNC@media.mit.edu

Abstract

This thesis examines the practical application of constructionist tools for leveraging the aggregate knowledge of a community. It introduces and develops the idea of a "constructionist cooperative," a community that shares its expertise via a knowledge database to facilitate richer individual project development. Inherent in this notion of a constructionist cooperative is the idea of the community itself generating the relevant content. The Pearls of Wisdom system (PoW) is a suite of computational tools designed to support constructionist cooperatives by facilitating asynchronous knowledge representation and sharing amongst community members. PoW includes two modules, the Pearl-Construction tool and the Pearl-Search tool, which support the construction and dissemination of Pearls, computational artifacts containing how-to project-design information. PoW supports community building via project sharing and community discussion. An evolving community-generated repository of Pearls becomes a reflection of the ideas and activities that are culturally resonant within the community and represents a collective perspective available for assimilation into the individual's perspective. This thesis will examine how PoW contributes to the cultivation of constructionist cooperatives and the dynamics of evolving a culture of knowledge sharing within a community. The Computer Clubhouse, a network of after-school technology centers where young people engage in constructionist design activities, will serve as the primary test-site for PoW. The Computer Clubhouse Network is currently expanding to more than 100 Clubhouses worldwide, connected by a private intranet portal where PoW will serve as a vehicle for the sharing of expertise across this widely distributed community. Through observation and analysis of the use of PoW at the Computer Clubhouse, I will develop new methodologies and approaches to guide research and practice in the development of such constructionist cooperatives and the appropriate technologies for supporting them.

1 Introduction

This proposal describes a dissertation that will answer the following questions: 1) in what ways can a community of learners create its own body of relevant knowledge so that community members can realize their individual objectives and 2) what role does technology play in cultivating and sustaining such a community?

A goal of this research is to develop a knowledge-building community where individuals contribute to the distributed expertise of the whole group. In a broad sense, a knowledge-building community is any group of individuals dedicated to sharing and advancing the knowledge of the collective (Scardamalia & Bereiter, 1994). Historically, a hindrance to the knowledge-sharing process has been the difficulties in connecting those with the knowledge to those who need it, particularly when physical or temporal constraints prohibit such sharing. Difficulty identifying local domain experts, the logistics of realizing physical connections, and barriers to overcoming social differentials, such as age and gender, all play a role in limiting knowledge-sharing (Chapman, 2001). Dealing with a geographically distributed community only exacerbates these obstacles.

A constructionist cooperative is a community that shares its expertise via a knowledge database to facilitate richer individual project development. In this thesis, I will discuss a new computational tool, called Pearls of Wisdom (PoW), which supports constructionist cooperatives by facilitating asynchronous knowledge representation and sharing amongst community members. Pearls, computational artifacts with meaningful project design content, are the basic unit of the PoW system. Each Pearl contains basic how-to information in a variety of media formats, the personal reflections of the author's learning experience, and for exchange of ideas in the form of contributed comments and links to Pearl-inspired projects.

As a tool, PoW can facilitate community-supported design experiences. For example, a member can search the PoW database for advice on how to create text or an image that appears engulfed in flames, the "fire-special-effect," using the Photoshop graphic design software. One member can attach her finished project to the same Pearl to show how she uses the fire-special-effect in her project. Another member can leave comments in that Pearl's discussion area about how he achieves the fire-special-effect using a different set of PhotoShop operations.

Members can utilize Pearls to achieve greater complexity in their design projects, and these Pearls become part of the distributed intelligence of the overall community. Pearl constructors share their design skills and insights from constructing and reconstructing Pearls. PoW makes it possible for the learner to be expressive of his thinking as part of his design process.

This research will contribute to the field by extending the theory of constructionist learning to include constructionist cooperatives. Constructionist learning happens when people are active participants in design activities that give them a sense of control over their learning process. When this learning takes place within the social experience, learners are encouraged to share what they have constructed with others. Within a constructionist cooperative, learners share not only their constructions but also their constructed knowledge with the community, which leads to a self-examination of an individual's learning process (Duckworth, 2001; Hutchins, 1995; Salomon, 1993). PoW supports this process through Pearl construction. Through their construction experiences, learners gain fluency in articulating their problem solving and learning styles. Just as constructionism encourages thoughtful reflection on one's learning experience, I will examine how constructionist cooperatives can support the construction of computational artifacts for deeper reflection, clearer articulation, and widespread sharing of individual knowledge with others.

In summary, this study will discuss the design of the Pearls of Wisdom system and the constructionist cooperative that evolves around it. I will develop a computational tool to support systemic organization of Pearls for dissemination to a larger community. It will provide a mechanism for searching for and creating new Pearls and include a mechanism for directing social feedback to the Pearl constructor. Additionally, I will describe a methodology for supporting the evolution of these constructionist cooperatives. Finally, I will show the effects of these activities on the individual and the community.

The organization of the remainder of this proposal is as follows:

- background relevant to this research, including theoretical underpinnings and review of related work
- description of the PoW system
- discussion of constructionist cooperatives
- study methodology and analysis
- timetable of deliverables and resource list.

2 Background

2.1 Theoretical Framework

This thesis introduces the concept of a constructionist cooperative, which has its roots in the theories of constructionism, distributed cognition, and the socio-cultural aspects of learning.

The term constructionism was coined by Seymour Papert, building on Jean Piaget's constructivist theory of learning that states that people learn by constructing their own cognitive structures in the context of their previous knowledge and environment (Piaget, 1977). Constructionism takes this theory further by stating people learn best when engaged in actively constructing external artifacts to share with and for critique by others (Papert, 1991; Resnick 1996). Papert argues that we learn through interacting with artifacts and gain an understanding of the world by creating and experimenting with artifacts, and modifying them to work better. Being out in the world, these artifacts provide a point-of-reference for sharing ideas within a community. Papert defines "objects-to-think-with" as objects that embody meaningful and important concepts, enabling learners to make contact with new ideas through their interactions with the objects. In his childhood play experiences, gears and cogs served as objects-to-think-with, providing him with mental models that gave concrete ways to think about the more abstract qualities of ratios, differential equations, and other powerful mathematical ideas, and led to his deeper understanding of mathematics.

The Logo programming language uses a "turtle" graphic as a computational object-to-think-with. Learners control the turtle's movements and drawing behavior to externalize their expectations or intuitions into the concrete. Their graphical design explorations lead to deeper insights into the concepts and properties of geometry. Papert exploits the turtle's computational and graphical power to make the ideas of mathematical abstraction and problem solving, once thought limited to the domain of adults, accessible to young people.

Pearls also serve as objects-to-think-with, both during their construction and during use. Pearl construction involves bridging the gap between personal knowledge and the symbolic representation of that knowledge. The construction process immerses the learner in a meta-learning process, giving him fluency in manipulating ideas by thinking about what he knows, deciding is important to convey to others, and settling on the right way to formalize his ideas so others can use them. By its support of this constructive process, the Pearl, in both its creation and use, becomes an object-to-think-with. As a Pearl is created, it functions as a tool for the transformation of individual knowledge from the conceptual into the concrete. As a Pearl is used, it provides scaffolding to support the learner in the exploration of new ideas.

Distributed cognition is a branch of cognitive science concerned with combining knowledge in the individual with knowledge in the world. It focuses on the social sharing of cognitive resources as a means of extending the individual's cognitive toolset to accomplish something she could not achieve alone. The basic unit of distributed cognition is a cognitive system consisting of the individual, the community, and socio-cultural cognitive tools (Salomon, 1993). I will look at PoW and its host community and analyze the complex, social distributed design activities in which computational artifacts such as Pearls play a significant role. I plan to identify if and how computational artifacts, such as Pearls, function as cognitive tools.

The focus of socio-cultural research is an examination of how co-construction of knowledge is internalized, articulated, and transformed in learning environments. The social aspect of learning reflects on the interdependence of social and individual processes in knowledge construction. According to Vygotsky, an individual's cognitive development is closely related to his social development; that is, learning takes place within a social context (Vygotsky, 1978; Wertsch, 1985). Vygotsky examined how people construct knowledge during their interactions with others and their environment, and identified what he called the learner's *zone of proximal development:* the differential between the actual level of development and the potential next level of development. Through collaboration or guidance from an agent (i.e., more capable peer), the learner can move into the next level of development. Agents within this *zone of proximal development* can include mentors, teachers, and artifacts. Generally, these more capable peers take on the responsibility of identifying a learner's needs and providing the necessary guidance. Pearls serve, in their both construction and use, as agents within the learner's *zone of proximal development*. PoW provides the scaffolding to help produce these artifacts, while leaving the responsibility of identifying particular support needs to the individual. That is, the individual must assume an active role in recognizing her own cognitive "impasses" and initiating the process of gaining access to a more capable peer.

The individual may choose to share their skills and ideas with others in the community (Dewey, 1963; Vygotsky, 1978). These exchanges add to the richness of everyone's learning process; we gain from the diverse perspectives of others and from sharing our perspectives with the larger group (Freire, 1970; Illich, 1971). Within a learning community, the individual and the collective interactively function to construct shared knowledge (Lave & Wenger, 1991). With such exchanges playing a key role in learning efficacy, it is important to provide tools to support learners in connecting their ideas with others. PoW is designed to provide these supports through facilities to construct and share ideas via Pearls and links to Pearl-inspired projects.

2.2 Related Work

Research in developing tools for knowledge sharing has been underway for some time. In this section, I will briefly describe three such tools: 1) a classroom-based tool for collaborative learning and inquiry, 2) a text-based environment for children to explore and share new ideas, and 3) a knowledge database to help children with their Lego constructions.

Computer Supported Intentional Learning Environment (CSILE) was the first network system to provide across-the-curriculum support for collaborative learning and inquiry (Scardamalia et al., 1989). CSILE students and their teachers create a communal database where students can enter text and graphic notes into the database on any topic their teacher has created. All students on the network can read the notes and comment on each other's ideas. Knowledge Forum, released in 1997, is the latest commercial form of CSILE. It is a component-based knowledge-building environment designed to support problem definition and hypothesizing, the collection and analysis of information, and collaboration in the classroom. One focus of CSILE and Knowledge Forum is the to examine new ways to design the classroom environment and harness technologies to support educationally productive processes. PoW looks at similar questions and provides a tool to use in less formal learning environments. One design focus of PoW is its community-building functions for motivating people to share their ideas with and learn from others. PoW is designed to provide functionality to support self and communal evaluation of an individual's work, encouraging cognitive and physical modifications, including re-framing and restructuring of ideas, assumptions, and representations. PoW will exist in a social environment where the learner makes the decision whether or not to construct Pearls or use the Pearls database; therefore, the tool must provide an easy to use interface that can easily and quickly support this iterative construction process.

"Multi-User Dungeons" (MUDs) are multi-player Dungeons and Dragons games played over the Internet. Amy Bruckman's MOOSE Crossing is a MUD designed especially for children: a text-based virtual world where they imagine and create new places and objects using words and programs (Bruckman, 1997). Bruckman's goal was to create a virtual space where children engage each other in a peer-supported form of learning. The focus was to examine how the Internet context could serve as a space for collaborative community learning. PoW follows this spirit of peer-supported learning, particularly with its facilitation of community dialogue. Our goal is to move beyond a text-based environment to include other types of media (e.g. audio, video, graphics), allowing richer, more flexible materials for idea exchange. This ultimately gives learners more flexibility in how they represent their ideas to others. Pearl mechanisms for contacting the Pearl creator, entering into Pearl-specific discussions, and linking new projects to a Pearl serves to deepen the community role in knowledge sharing.

The vision of the Constructopedia (Papert & Resnick, 1995) is to develop a searchable, interactive database that assists children in working on design projects and making connections to the math and scientific ideas underlying those projects. Although implemented in only simple prototypes so far, the goal of Constructopedia is to provide systematic how-to information intended for designer use. Each entry in the database contains examples, explanations, and visuals related to that entry's topic. PoW has a similar goal as Constructopedia but extends the idea to using a community of learners as the source for the knowledge database. The larger goal is to cultivate a constructionist cooperative, where working on a viable project can mean designing photo collages, composing music, or constructing Pearls

3 The PoW System

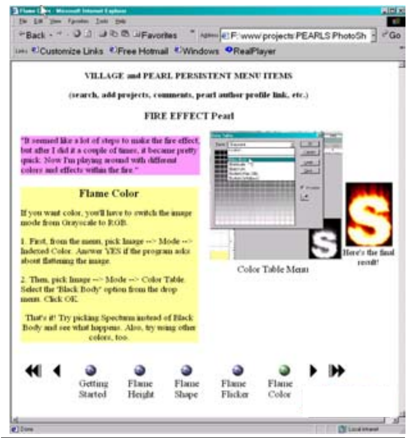
Pearls, the basic unit of the PoW system, are computational artifacts created by community members, which contain how-to project-design information. Figure 1 shows a portion of a Photoshop Pearl[1] for making text or images that appear to be on fire.

(a)

(b)

[1] This early prototype design did not include the community feedback, output, or Pearl author-recognition mechanisms.

The Pearl content contains the creator's thoughts and ideas, her instructions for others to follow, and examples to support her explanations.



(c)

Figure 1. PhotoShop Fire-Effect Pearl. Screen (a) shows sample projects, so users will know they have found the right Pearl. Screens (b) and (c) contain information, in various media formats, describing some of the steps for making a fire-special-effect. These are excerpts from a Pearl consisting of 5 screens.

Individuals access Pearls by using the Pearl-Search tool to browse the database for ideas or locate Pearls on specific topics. Pearl construction takes place when a community member decides to add his or her own design expertise to the database. A continuum of people seeking the help of an evolving repository of Pearls and reaping the benefits of formalization of their knowledge is a cycle that characterizes the PoW Flow of Support, as shown in Figure 2.

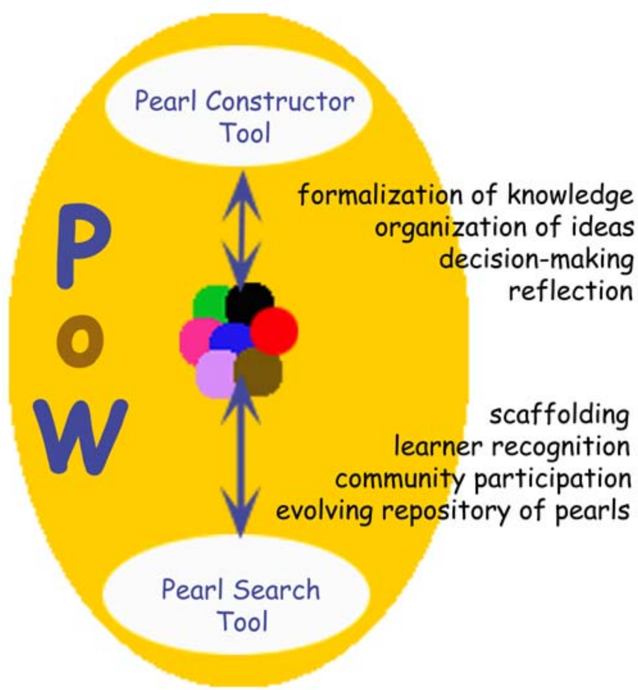


Figure 2. PoW Flow of Support.

The PoW system consists of two modules: 1) the Pearl-Construction tool and 2) the Pearl-Search tool. The Pearl-Construction tool assists in the organization of ideas and reflection on the learning experience. People constructing Pearls must consider what narrative and media best express their understanding in ways meaningful to others. The Pearl-Search tool contains a search engine for identification of a desired Pearl and a graphical user interface for navigating Pearl content.

The Pearl-Construction tool is a constructionist tool for building Pearls and has the facility for importing objects such as text blocks, video, images, audio, plug-ins, and hyperlinks. People constructing Pearls can organize these objects to achieve a suitable expression of their ideas. Through their Pearls, they can also share their learning experiences, design experiences, and/or Pearl-making insights.

Consider the following scenario:

> *Sue has been working with the Photoshop graphics program to make a collage of her family, classmates, friends, and favorite places. She adds the title, "Sue's World," across the top of the project. So far, it looks good, but after some consideration, Sue decides, she needs something to give it extra zing. While browsing the PhotoShop area of PoW, she comes across the fire-special-effect Pearl. "Hmm, I like this, it looks just like real fire." Sue pages through the Pearl and follows the steps to add fire to her project. The result surprises her because it looks professional, like something out of a magazine. Sue prints several copies of her project to take home and show her parents and friends at school.*
>
> *Getting so much praise and attention from her first Pearl-supported project felt great and Sue liked how using the Pearl helped her make use of more advanced PhotoShop operations. She decides to make a Pearl of her own and looks over some of her older projects to find something interesting. She notices how cool one of her PhotoShop project featuring some "glowing orbs" looks and decides to create a Pearl about using PhotoShop to create a glowing orb. This is the first time she is constructing a Pearl and she checks out the Pearl-Constructor program to see if it looks easy to use. She notes that she can put stuff in any of three areas of the Pearl, the reflection, how-to, and examples. This looks straightforward, so Sue decides to skip the reflection area and just add two of her glowing-orb-effect projects to the example area. Now she has to add her explanation of how to do the glowing-orb effect into the how-to section of the Pearl. Sue is unwilling to write*

every detail about making the special effect; that would take too long. Instead, she decides to just describe the parts that were tricky to figure out on her own. Looking over the finished Pearl, Sue realizes it is okay but not great. She decides to leave a message in the reflection area saying she will spend more time on it if she hears from anyone. She selects "add Pearl to database" and goes back to working on her current project.

Certainly, we hope that users, such as Sue in the above scenario, will return and improve on their Pearls. We expect more similar Pearls will be added to the knowledge database, as there is no restriction on the creation of similar Pearls by different community members; all submissions become part of the knowledge repository. Given a choice of similar Pearls, the community will "vote with their minds" by using those Pearls they deem most helpful. This could lead to an expectation of a particular quality of Pearls and provide incentive for Pearl constructors to provide that quality.

3.1 POW Software Architecture

There are three primary PoW interfaces: 1) the Pearl interface, 2) the Pearl-Constructor interface, and 3) the Pearl-Search interface.

3.1.1 The Pearl Interface

Pearl real estate is divided into areas dedicated to navigation, community functions, output functions, and Pearl constructor recognition, all surrounding a content-filled information area. Figure 3 shows a layout of the Pearl user interface.

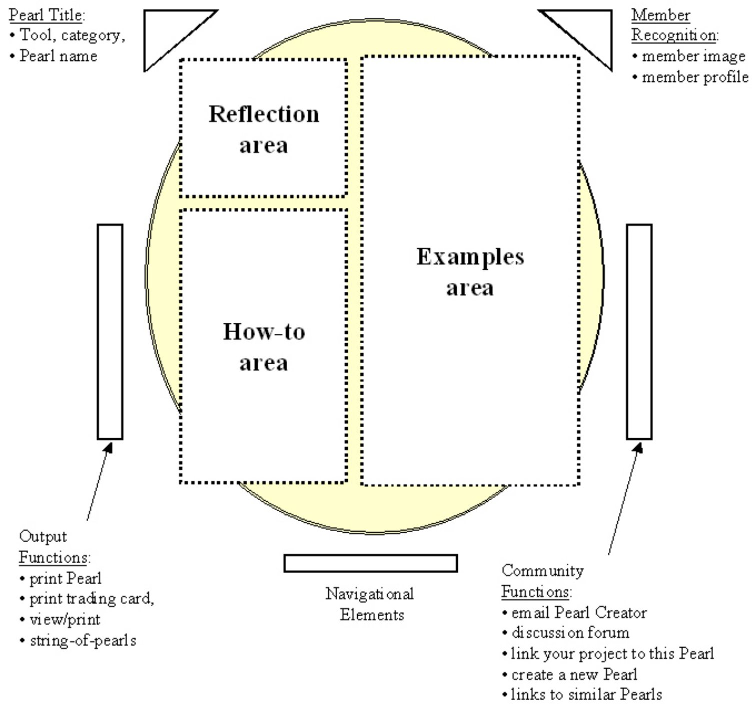


Figure 3. Pearl Layout

Navigational Elements include buttons for easy access to any of the one to five existing Pearl content screens. The Community Functions include a discussion forum, an email link to the Pearl constructor, an option for the Pearl user to link their Pearl-inspired project to the Pearl, and a “create a new Pearl” option. The Member Recognition area contains the Pearl creator’s image or logo and a link to their user profile. The Output Functions area allows a printer-friendly version of the Pearl, a trading-card version of the Pearl[2], and access to the user’s personal “string of pearls[3].” The Pearl content is organized in three areas: reflection, how-to, and examples. The reflection area contains whatever the Pearl constructor wants to share with the community. The how-to area contains the steps to achieve a new design skill. The Examples area is for adding animations, drawings, plug-ins, or whatever media the Pearl creator feels best expresses what she knows. Figure 4 gives a more detailed explanation of the specific program functions available to the user within the Pearl interface.

[2] Thanks to Rick Borovoy for this suggestion.
[3] String-of-Pearls is a visual, historical record of all the Pearls the user has ever visited on the system.

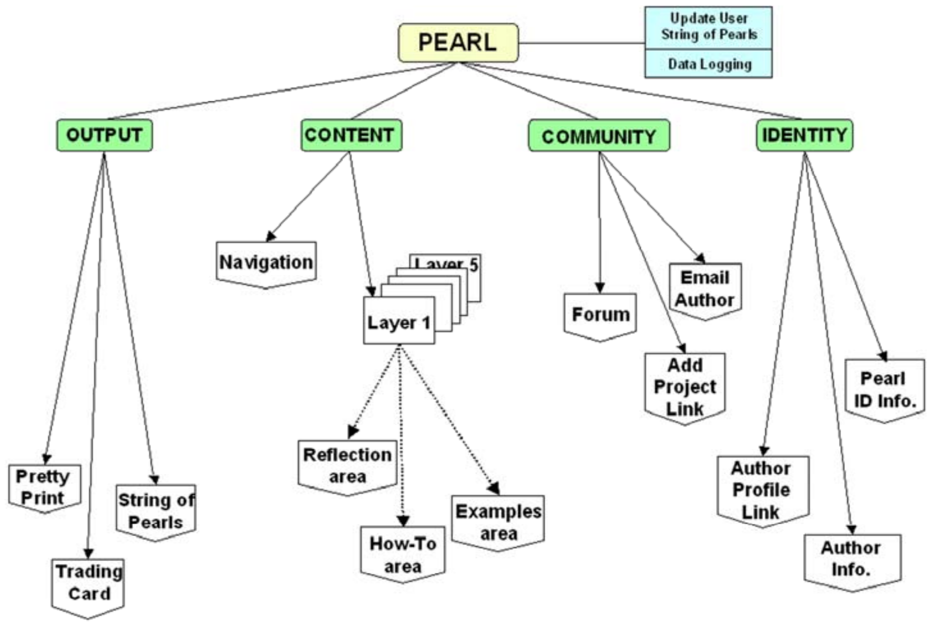


Figure 4. Pearl Schema.

In summary, this Pearl interface design is to provide a user interface that incorporates features to motivate Pearl creation, use, and community participation. Key design elements include the following:

- *Creator recognition.*
- *Community functions.*
- *Artifact instantiation.*
- *Printing Options.*

3.1.2 The Pearl-Constructor Tool

The Pearl-Constructor tool, which includes a simple editing and media-object toolset, is designed to provide an easy to use authoring environment to quickly construct Pearls with a minimal time investment. Figure 5 shows a layout of the Pearls-Constructor tool user interface.

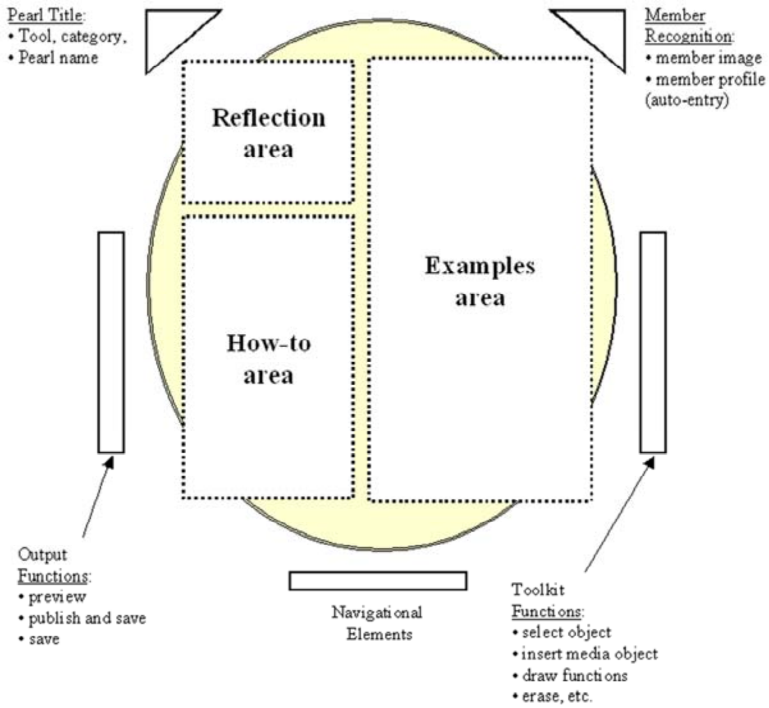


Figure 5. Pearl-Constructor Layout.

The Pearl creator can resize the reflection, how-to, or supporting information areas to fit his or her design needs. The goal of this Pearl-Constructor tool design is to provide a user interface that incorporates features to motivate Pearl creation and re-creation. Key design rationales include the following:

- *Low-threshold for tool*. An iconic interface and simple editing toolkit are chosen to make it easy to use the Pearl-Constructor without prior training. However, the interface is flexible enough that Pearl designs themselves can be as complex as the individual user desires.

- *Quick "return on time investment*." Pearl-Construction minimally requires the creator's identity information, Pearl title and category, and input to the how-to section.

- *Edit after publishing.* Even after publishing a Pearl, the creator can always go back and make changes. This allows for a iterative design cycle where the creator may decide to make changes based on community feedback or his own sense of what constitutes a more concise explanation of the Pearls content. It also saves the frustration of having to re-create a better Pearl from scratch.

- *User Control.* The Pearl creator decides when to publish, giving the same level of control over dissemination of work as with other design projects.

Figure 6 gives a more detailed explanation of the specific program functions available to the user within the Pearl-Constructor interface.

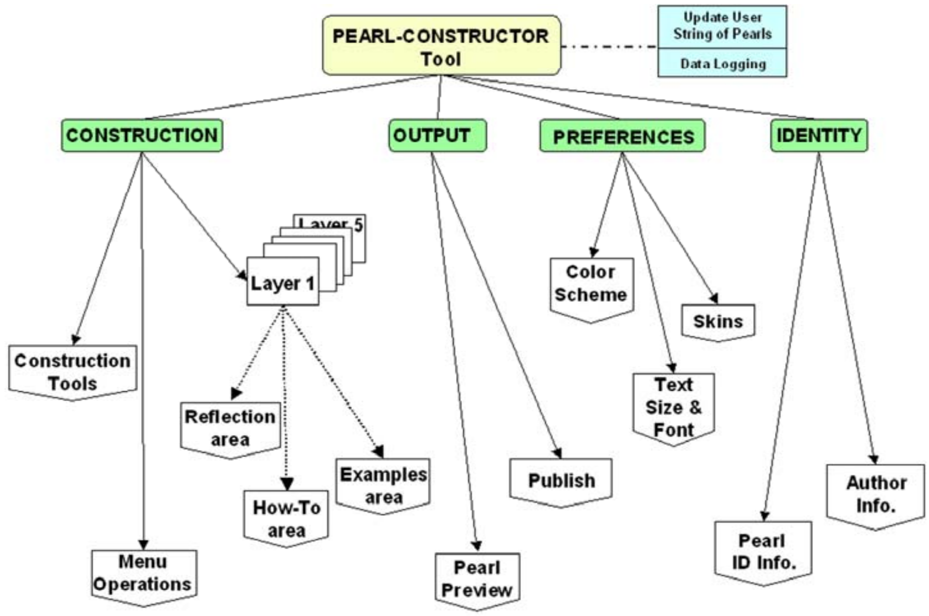


Figure 6. Pearl-Constructor Tool Schema.

3.1.3 The Pearl-Search Tool

The Pearl-Search tool contains search and browse mechanisms to help users explore new ideas and to locate specific Pearls. The Pearl-Search tool is designed to enhance the user-driven design process and support the spread of new ideas. Learners can browse for new elements to include in their projects, which we hypothesize will lead to realization of more complex projects, more instances of learners trying out new things, and more opportunities for more database exploration for locating similar Pearls. The user interface is organized into three sections containing search/browse, community, and individual tools. Figure 7 shows a layout of the Pearl-Search tool.

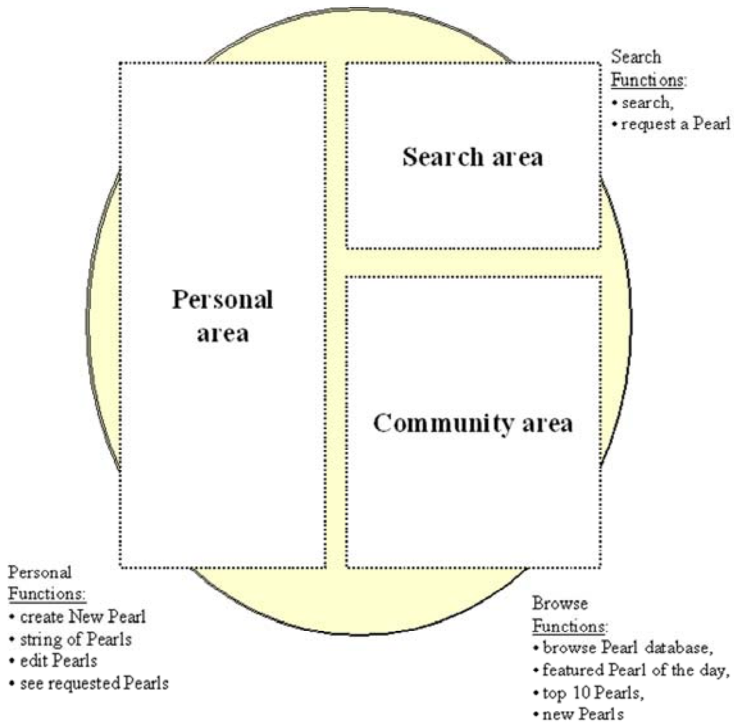


Figure 7. Pearl-Search Layout.

The goal of this Pearl-Search tool design is to provide user interface features that make finding relevant Pearls easy. We hypothesize that improving ease of search could stimulate community interactions as more people use PoW. Key design elements include the following:

- *Personal area.* The user can create a new Pearl, edit existing Pearls, or view her current String-of-Pearls.
- *Search area.* Look for Pearls by category for new project ideas or perform a search for a specific Pearl.
- *Community area.* View the featured Pearls, check out Pearls recently added to the knowledge repository, or review the most frequently used Pearls.

Figure 8 gives a more detailed view of the specific program functions available to the user within the Pearl-Search user interface.

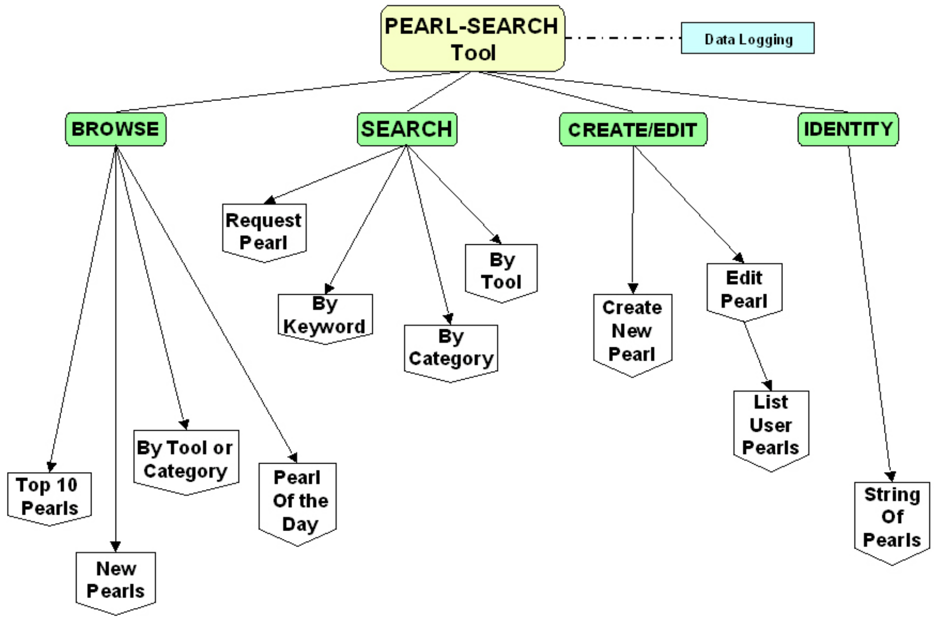


Figure 8. Pearl-Search Tool Schema.

4 Constructionist Cooperatives

This research project contributes to the theory of constructionism by introducing and developing the idea of a constructionist cooperative and examining its role in enriching individual learning experiences. A constructionist cooperative is a community that shares its expertise via a knowledge database to facilitate richer individual project development. The synergy implicit in constructionist cooperatives represents a fundamental shift in how we view communities supporting their enhanced functioning, by becoming active creators of relevant content rather than passive consumers of provided information. Fluency with digital technologies and content creation becomes a statement of an individual's sense of empowerment to effect change in his or her life (Resnick, 2001; Pinkett, 2001; Chapman & Burd, 2002). Appropriate constructionist cooperative technologies can support these activities. Throughout the course of this research project, we expect to gain a deeper understanding of the practical issues involved in establishing and sustaining constructionist cooperatives and their impact on the functioning and dynamics of a community.

4.1 Role of Community in Knowledge Building and Knowledge Sharing

One benefit of the externalization of personal knowledge as a Pearl is the engagement in reflection on that knowledge during construction. The act of Pearl creation requires an internal dialogue as learners think about what they understand, how old knowledge links to new knowledge, and what aspects of knowledge are crucial to shared understanding. There is great value in reflecting on one's knowledge because it supports the meta-learning process (Jonassen, 1991; Salomon & Perkins, 1998; Duckworth, 2001).

Knowledge sharing in the context of a social setting becomes more than just information sharing; it is the sharing of experiences, observations, values, and vocabulary. Within a community setting, motivation to share knowledge comes from the community itself, both through direct requests and through the prestige afforded to the knowledge creators. Finally, through knowledge sharing, individuals experience their own *zone of proximal development* (Vygotsky, 1971) when they advance their own understanding by learning from others more advanced in a practice than they are.

The overall goal of PoW is to allow a constructionist cooperative to develop into a "learning web (Illich, 1971)," where members of a community can play an important role in the creation and dissemination of knowledge in a form that everyone can use. This dynamic casts community members into the role of both teacher and learner depending on the circumstances. People learn what they need from whomever they need when they most need it. I hypothesize that constructionist cooperatives will serve as a medium for learners to become active producers of knowledge that becomes usable by the community because of their own self-directed learning activities. Some important contributions of a thriving constructionist cooperative include the following:

- providing access to available digital resources or artifacts, in this case Pearls and the PoW system.
- empowering community members to share what they know with others who want to learn from them.
- giving the community a voice in the knowledge-sharing process, as peers give feedback and contribute content of their own.

4.2 Challenges to Community Knowledge Sharing

Communities vary in the level of knowledge sharing that is part of the social norm. Even in cases where knowledge sharing is present, there often remain challenges to deeper forms of sharing. Some of these challenges include difficulties identifying peers that are more capable and overcoming social differentials, such as age and gender. There are also logistical problems of connecting people beyond their local environments and supporting their articulation of ideas to others.

Compare the following scenario to an earlier example:

> *Sue, a young learner, needs help building a shadow effect for an image of her pet cat which she has imported into the PhotoShop graphics program. She is good at basic editing in PhotoShop, but has not had much experience with special effects. Sue asks her friend Andy, who is working nearby for help, but he does not know what to do either. Though an adult mentor offers to help, he is also unfamiliar with the technique of producing shadow effects. Eventually, Sue gets discouraged and drops the project.*

Obviously, obstacles are very difficult to circumvent if face-to-face meetings are the sole option for knowledge sharing. In Sue's case above, she was unable to locate someone locally to help her get to a deeper understanding of PhotoShop. While there may indeed be another learner in the community who has the knowledge she needs, being unable to make a successful connection constrains her learning process and design experience. Difficulties arise in connecting those who have the knowledge to those who need it, particularly when there are prohibitive physical or temporal constraints to overcome.

4.3 Cultivating a Constructionist Cooperative

There are two questions to answer if we are to mindfully cultivate constructionist cooperatives. How does the practice of sharing knowledge become part of the social fabric of a community? How can learners recognize when they have something worth sharing?

Infusing new technologies and ideas into an established community can be a daunting task. Similarly, promotion and acceptance of technology tool, such as PoW, within the community brings with it a myriad of challenges. In the constructionist community, there are no mandates to what the learner should learn and when to learn it, instead the learner makes these determinations. That is, even when knowledge sharing is common to a culture, the use of a technology like PoW is a new idea. Consequently, the new idea for sharing knowledge must "catch on" before being adopted wholeheartedly.

Identifying what a community may already value around knowledge sharing is important to note and care must be taken to not disrupt these processes when introducing PoW or other technologies into the community. For the purposes of this discussion, we will assume a community that practices knowledge sharing in the form of project display and face-to-face mentoring. I will discuss this assumption further in Section 5.

Cultivating a constructionist cooperative around PoW requires community-sanctioned motivations for creating and using Pearls. Motivation for creating Pearls is not an intuitive one, and many factors come into play, including 1) personal status gained from recognition of an individual's work by the larger community, 2) peer requests for individuals to contribute concrete instantiations of their knowledge, and 3) desire to maintain a historical presence in the community even once the individual is no longer an active community member.

When members enjoy a higher social status due to their recognition as an "expert," they are motivated to improve their design skills and share what they have learned with others. PoW supports this recognition dynamic by ensuring that Pearl constructors are "seen" by community members using their Pearl. Receiving comments from Pearl users also assures the Pearl constructor that his Pearl is being utilized and is valuable to the community.

Peer requests for particular Pearl topics are a strong motivator for community members contributing to the knowledge repository. Over time, members gain a sense of what topics and tools others have the most questions about. Individuals also gain a perspective of how to parcel out their design knowledge in a form that is usable by the community.

When members leave their community or are no longer able to be active in the community, there is a sense of loss of both their status and of the value of their former contributions. From a historical perspective, the impact of their presence and contributions "fades" from the collective memory over time. By contributing Pearls to the community, members create a permanent artifact and marker of their membership in the community. Those individuals can still serve a beneficial role and continue to be recognized by their former community.

5 Empirical Study

5.1 Site Selection: The Computer Clubhouse Network

The Computer Clubhouse Network is a network of after-school technology centers where underserved youth participate in constructionist, project-based learning activities with the support of adult mentors. The Computer Clubhouse was founded in 1993 by The Computer Museum (now part of the Boston Museum of Science) in collaboration with the MIT Media Lab. Within the Clubhouse environment, members share what they know with members who are less expert. Members work closely with adult mentors: students, and professionals in fields such as media arts, science, technology, and creative writing who share their experience and serve as role models. The Clubhouse educational approach is based on research that shows the importance of interpersonal relationships and community in the learning process (Resnick & Rusk, 1996). Four guiding principles of the Computer Clubhouse learning model are:

- To focus on "constructionist" activities, encouraging young people to work as designers, inventors, and creators.
- To encourage youth to work on projects related to their own interests.
- To create a sense of community, where young people work together with one another with support and inspiration from adult mentors.
- To provide resources and opportunities to those who would not otherwise have access to them.

The goal of this constructionist-learning model is to give participants the opportunity to become active designers and creators of technology, not just passive consumers. Computer Clubhouse members work on a variety of self-motivated projects in areas such as computer simulations, multimedia creations, electronic music, computer game design, kinetic sculptures, 3D design, web page development, and programming.

Design activities serve as an educational medium that engage learners as active participants and make contextual connections to the knowledge they gain. These activities often are interdisciplinary in nature, providing exposure to a variety of concepts and requiring creative problem solving. Working on design activities within a supportive community environment provides the additional benefit of aiding the learners' reflection through sharing and discussion. With the model's success, the Computer Clubhouse earned the Peter F. Drucker Award for Nonprofit Innovation in 1997 and a grant from Intel in 2000 to fund the opening of one hundred new Computer Clubhouses, worldwide. The increasing number of Computer Clubhouses, across diverse cultures, offers a unique opportunity for distributed knowledge sharing of design perspectives throughout the Computer Clubhouse network. Because a culture of sharing knowledge is part of the Computer Clubhouse learning community , the Computer Clubhouse was chosen as the test site for the PoW system.

5.2 Methodology and Analysis

We will examine how individuals and the Computer Clubhouse community as a whole make use of PoW and what new communities of practice evolve from PoW-supported interactions. We go further to look at how Pearls function as computational artifacts.

5.2.1 Methodology

We will record baseline measurements taken before the introduction of PoW. These measures include the following metrics:

- member perception of how knowledge-sharing happens at their Computer Clubhouse
- the ways members share personal knowledge, and the levels and mechanisms of project design proliferation throughout their Computer Clubhouse
- the degree of Computer Clubhouse involvement in individual members' learning process
- member perception of their own control over their learning process
- the role of member status in the community and what enhances that status, and
- member perception of their ability to articulate their ideas.

I will make these measures again at the end of the study for comparison to the baseline. I will conduct case studies, identifying a member, mentor, and Computer Clubhouse in order to obtain a broader perspective on the impact of constructionist cooperatives. I will select at least three case study participants from the Computer Clubhouse community of varying ages, genders, and demographics. In particular, we will look at the impact of knowledge sharing in each of these cases, including:

- circumstances that encourage knowledge-sharing
- motivation to transfer knowledge from project designs to Pearls
- member perspective of control over articulation of ideas
- relative quality of Pearls and associated community discussion
- the ways members' status provide incentive to make Pearls, and
- the impact of PoW on members' expertise development.

5.2.2 Analysis

My selection of evaluation methods for this study is influenced by Ann Brown's "design experiments" (Brown, 1992), which illuminate how to incorporate learning innovations and technologies into a theory-based design and implement than into a live setting over a series of continuing research cycles. The results of previous cycles then serve as controls for subsequent cycles. The design experiment must have predictions testable through the data collected during the live experiment. Design experiments serve to meet experiential requirements; variables are randomized, controlled, and manipulated across a wide range of test subjects. Brown recommends this method of experimentation to ensure the research and results represent "the big picture" of the learning environment and become a measure of the impact that learning technology.

I have selected a combination of both qualitative and quantitative methods that give an observational and statistical view of the study results, including:

- A pre-test to compile PoW user background information and obtain a pre-PoW snapshot of shared learning and community dynamics at the Computer Clubhouse.
- A post-test consisting of open-ended questions and experiential questions.
- Informal observations via repeated visits to the Clubhouses where the PoW is in use, of users engaging with the PoW software.

Using Brown's methods, I will study the impact and evolution of PoW within Computer Clubhouse culture via survey instruments, observational fieldwork, interviews, case studies, and formative evaluation. These data will be subject to both qualitative and quantitative analyses. Qualitative analysis will provide insight into how the Computer Clubhouse community adopts and uses PoW and will provide much-needed context for any quantitative results. We will instrument the Pearls environment to capture user actions such as usage patterns and trends, and we will collect, analyze, and report aggregate user information by Clubhouse and across the Computer Clubhouse Network.

Other data collected will include an examination of PoW features used, characteristics of new contributions, and temporal characteristics of the Pearl construction cycle. Subject interviews and targeted surveys will provide qualitative feedback from subsets of the Computer Clubhouse community. I will systematically record, transcribe, and categorize on-site observations. Computer logs of user transactions on PoW will also be recorded. Subsequent to the collection and analysis of the quantitative and qualitative data, a final analysis will be prepared. This analysis will summarize the results of this study, including any lessons learned, exemplars, recommendations, and conceptual framework for establishing constructionist cooperatives. I hope to address the question of how PoW influences the learner and designer experiences. Some measures may be increases in the quality of an individual's organization, presentation, reflection, or project management skills. I also hope to address the question of how members do or do not translate their PoW experience to real-world strategies.

6 Schedule of Research

This research project will proceed in two phases:

Phase I:

- Make baseline measurements.
- Develop PoW suite of programs.
- Seed PoW repository with representative examples of at least twenty Pearls spanning the wide range of tools available at the Clubhouse.
- Recruit Computer Clubhouse mentors, network-wide, to contribute to the seeding effort.
- Select set of members to begin using the Pearl-Search tool.
- Make observations, interviews, and surveys to inform further PoW development, updates, and interface organization.
- Evaluate the Pearl-Search tool for suitability and accessibility to the community.
- Introduce Pearl Constructor tool to a small group of mentors and members, who will use the constructor tool without training to assess its usability.

Phase II:

- Make PoW available to the entire Clubhouse community.
- Hold promotional events and activities to introduce the technology to the Computer Clubhouse community and support development of a constructionist cooperative.
- Record usage data and server log analysis to provide information about PoW activity levels and characteristics of Pearl creation and use.
- Perform impact studies on individuals identified for case study.

6.1 Deliverables

Deliverables will include a conceptual framework for developing and cultivating constructionist cooperatives, development of suitable prototype PoW platform, validation of this design approach, and dissemination of results of studies at the Computer Clubhouse. Finally, there will be a discussion of the types of interactions made possible by the introduction of this technology and how constructionist cooperatives become part of the social dynamic of a community.

6.2 Timetable

April 2002	Proposal completed
Spring 2002	Phase I starts.
Summer 2002	Phase I continues.
Fall 2002	Phase II starts.
IAP 2003	Phase II complete.
Spring 2003	Final analyses and write up.

6.3 Resources Needed

- Travel to Computer Clubhouse sites for PoW training and special events.
- Travel to conferences for presentation of papers and other deliverables.
- Computer hardware and software, including web server and application server as a development test bed.
- Microsoft SQL Server 2000 Client Tools, IIS Application Server, Java SDK, Enterprise Java Beans, JRun 3.1, CVS Development Environment, and other applicable software.
- Clubhouse intranet design specifications (from Intel).
- UROP students, including 3 programmers and 1 fieldwork assistant.

References

Brown, A.L. (1992). "Design Experiments: Theoretical and methodological challenges in evaluating complex interventions in classroom settings." *The Journal of the Learning Sciences*, No. 2(2), pp. 141-178.

Bruckman, A. (1997). "MOOSE Crossing: Construction, Community, and Learning in a Networked Virtual World for Kids." Diss. Massachusetts Institute of Technology, Cambridge, MA.

Bruckman, A. (1998). "Community Support for Constructionist Learning." *Computer Supported Cooperative Work*, Vol. 7, Nos. 1 & 2, pp. 47-86.

Chapman, R. (2001). "Redefining Equity: Meaningful Uses of Technology in Learning Environments." Position Paper presented at *IEEE International Conference on Advanced Learning Technologies (ICALT 2001),* Madison, WI.

Chapman, R. and Burd, L. (2002). "Beyond Access: A Comparison of Community Technology Initiatives." In *Proceedings Informatica 2002, The Latin American and Caribbean Symposium on Education, Science and Culture in the Information Society - SimpLAC 2002,* pp. 68-75.

Dewey, J. (1897). My pedagogical creed. *The School Journal,* No. 543, pp. 77-80.

Dewey, J. (1963). *Experience & Education.* Collier MacMillan, NY. (Original work published in 1938)

Duckworth, E. (2001). *"Tell Me More," Listening to learners explain*. Teachers College Press, NY.

Evard, M. (1996). "A Community of Designers: Learning through Exchanging Questions and Answers," In *Constructionism in Practice: Designing, Thinking and Learning in a Digital World*, Y. Kafai and M. Resnick, eds., Lawrence Erlbaum Associates, Mahwah, NJ, pp. 223-240.

Freire, P. (1970). *Pedagogy of the oppressed*. Continuum, NY.

Harel, I. (1991). *Children Designers*. Ablex Publishing, Norwood, NJ.

Hutchins, E. (1995). *Cognition in the Wild*. MIT Press, Cambridge, MA.

Illich, I. (1971). *Deschooling Society*. Harper & Row, NY.

Jonassen, D. H. (1991). "Evaluating constructivist learning," *Educational Technology,* No. 31, pp. 28-33.

Lave, J., and Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press, Cambridge, UK.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas* . Basic Books, NY.

Papert, S. (1993). *The Children's Machine*. Basic Books, NY.

Papert, S. (2000). "What's the big idea: Towards a pedagogy of idea power." *IBM Systems Journal*, Vol. 39, pp. 3-4.

Papert, S., and Resnick, M. (1995). Technological Fluency and the Representation of Knowledge. *Proposal to the National Science Foundation,* MIT Media Laboratory, Cambridge, MA.

Piaget, J. (1977). "The Essential Piaget (Part IX)." Gruber, H.E. & Voneche, J.J., eds., Basic Books, NY.

Pinkett, R. (2001). "Creating Community Connections. Socio-cultural Constructionism and an Asset-Based Approach to Community Technology and Community Building in a Low-Income Community." Diss. Massachusetts Institute of Technology, Cambridge, MA.

Resnick, M. (1996). “Towards a Practice of Constructional Design,” In *Innovations in learning: New environments for education,* L. Shauble and R. Glaser, eds., Lawrence Erlbaum, Hillsdale, NJ.

Resnick, M. (2001). “Closing the Fluency Gap,” *Communications of the ACM*, vol. 44, no. 3, pp. 144-145.

Resnick, M., and Rusk, N. (1996). “Access is Not Enough: Computer Clubhouses in the Inner City,” *American Prospect*, No. 27, pp. 60-68.

Salomon, G. (1993). “No distribution without individuals' cognition: A dynamic interactional view,” In *Distributed cognitions,* G. Salomon, ed., Cambridge University Press, NY, pp 111-138.

Salomon, G. & Perkins, D.N. (1998). Individual and Social Aspects of Learning. In *Review of Research in Education*, P. Pearson & A. Iran-Nejad, eds., American Educational Research Association, Washington, D.C. Vol. 23, pp.1-24.

Shaw, A. (1995). “Social Constructionism and the Inner City.” Diss. Massachusetts Institute of Technology, Cambridge, MA.

Scardamalia, M. & Bereiter, C. (1994). “Computer support for knowledge-building communities,” *Journal of the Learning Sciences*, 3(3), pp. 265-283.

Scardamalia, M., Bereiter, C., McLean, R., Swallow, J., & Woodruff, E. (1989). “Computer-Supported Intentional Learning Environments,” *Journal of Educational Computing Research*, Vol. 5, No. 1, pp. 51-68.

Vygotsky, L. (1978). *Mind in Society: The development of higher psychological processes.* Harvard University Press, Cambridge, MA.

Wertsch, J.V. (1985). *Vygotsky and the social formation of mind.* Harvard University Press, Cambridge, MA