

Methods and Techniques for Involving Children in the Design of New Technology for Children

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Abstract

Children have participated in the design of technologies intended to be used by children with varying degrees of involvement, using diverse methods, and in differing contexts. This participation can be characterized as involving children as *users*, *testers*, *informants*, or *design partners*. It is only relatively recent that researchers around the world have begun to work more substantively with children to design technologies for children. This monograph synthesizes prior work involving children as informants and design partners, and describes the emergence of participatory design methods and techniques for children. We consider the various roles children have played in the design process, with a focus on those that integrally involve children throughout the process. We summarize and provide a pragmatic foundation for fellow

researchers and practitioners to use several methods and techniques for designing technologies with and for children. In this monograph we relate the techniques to the design goals they help fulfill. The monograph concludes with a consideration of working with children in technology design processes as we move into the twenty-first century.

1

Introduction

You walk into a university lab to observe a technology design session. Although the technology to be designed is for children, you expect to see computer scientists working diligently at computers, educators offering their input on the latest developmentally appropriate research on children, and information technology specialists guiding the interface design. The room might be hushed while everyone works diligently. Instead, you witness the following:

The brightly colored lab is abuzz with noise and laughter, not only from the aforementioned hardworking computer scientists, educators, and information technology specialists, but also from children! The group is finishing up eating a snack together, at which point one adult explains that during today's session, the team will be working to solve interface design issues for a major online company. The group is then split up into smaller teams of three to four members, each with adults and children who will work together on the problem.

These groups disperse across the room and begin to build ideas using giant bags of art supplies. Children and adults are on the floor working together, creating models, discussing possibilities, and devising solutions. As the ideas flow, the activity level in the room increases. Children and adults alike are writing, building, talking, and collaborating. Ideas emerge from each group.

An adult leader calls everyone back together, and children and adults from each group work together to present the ideas they came up with to the large group. From a disco ball interface that would allow combining searches, to redesigned keyboards, to auditory feedback and hints on spelling, the groups have come up with many ideas to solve the problem of how children search for information on the open web.

This scenario describes an actual design session of *Kidsteam*, an intergenerational technology design team using the *Cooperative Inquiry* method of design partnering [28, 29, 32] at the University of Maryland. These child design partners participate in sessions such as the one described above on a regular basis in order to design new technologies for children. We believe it is important to include children in designing technology intended for use by children especially as technology is becoming more and more prevalent in the lives of all children.

Today's technologies in the home are becoming ubiquitous, not just for adults, but also for children of varying ages, in diverse contexts, and in different countries [33]. A 2008 report from the Pew Charitable Trust found that families with children are more likely than other family configurations to have various types of technology in the home. These technologies include computers, the Internet, broadband access, and mobile phones [70], and the use of these technologies is significant. In fact, another study reports that computers were used by 27% of 5–6-year-olds on a daily basis, for an average of 50 minutes [114], 80% of households of children 6-years-old and under owned a computer or

laptop, and approximately 69% of all households with young children had Internet access. Of 3- to 10-year olds in 2011, 55% used handheld gaming devices, 68% played on console gaming devices, and 85% used computers [111]. Even longtime media giants such as the Sesame Workshop have divisions dedicated to interactive technology [100]. Children's technology use in school also continues to increase. This increase exists in early childhood [33], and continues through public schools in kindergarten through twelfth grade. According to the National Center for Education Statistics (NCES), in 2009, 97% of teachers in the U.S. reported having a computer in the classroom, and of those, 93% had Internet access [86]. This increased presence of technology in children's lives is also a world-wide. Among children aged 8 to 18 across Japan, India, Paraguay, and Egypt, 69% use mobile phones [49]. Indeed children's use of these technologies in diverse contexts is significant and it continues to increase.

With technology impacting children of many ages and contexts on a global scale, there has been considerable research in the educational sector that has focused on the proliferation of technology and its impact among children both at home [33, 70] and in school [33, 86]. This research leaves an aspect of technology that is sometimes overlooked in research: the design of technology. For a technology to come into being, someone, or some people, somewhere, spent a lot of time and effort first conceiving the idea for the technology, then developing and building the technology, then implementing the technology in the context for which it is intended, and finally testing the new technology with the intended users, which in this case is children.

All technology must be designed and implemented, however it is not given that children are an integral part of the design process [29]. Research has shown that children can be involved in the technology design process in a variety of ways [29]. This monograph reviews the research and practices of involving children in the technology design process, with a particular focus on methods and techniques that integrally involve children in these processes. This monograph offers designers of children's technology motivation and practical ideas for including children in the technology design process.

1.1 Terminology

Before proceeding, it is necessary to define some of the terms that will be repeatedly used throughout this monograph. While many of these terms seem common in their usage, different readers may have different perspectives and experiences, so we discuss each of these terms as they will be applied in this monograph. Specifically, we define and distinguish what we mean by: *child*, *technology design process*, and *technique vs. method*.

1.1.1 Child

Hourcade [60] expresses that we should consider developmental needs of children in the technologies being designed for them. We extend this notion to also considering the developmental needs of children as they are included in the design process. The age of the children of principal focus in this monograph are elementary school aged children (6 to 12 years of age), and the methods and techniques discussed are primarily for children in this age range. Some of the methods have variations for children who are as young as 3, and as old as 16. Most children involved in reported research on children in technology design processes are in the developmental stage often referred to as middle childhood, ages 7 to 11 years old. Druin [28, p. 596] found that 7–10-year-olds work well as design partners in technology design process contexts as they are “... verbal and self-reflective enough to discuss what they are thinking”. This age range falls within Piaget’s concrete operational stage which is typically children aged 6 to 12 which means they can think logically with concrete information, but have more difficulties with abstract concepts which is why many techniques have concrete objects to help bridge their thinking [75]. Erikson’s industry vs. inferiority stage includes children aged 6 to puberty. During this stage children become more able to cooperate with others thus supporting a collaborative work approach [13]. Therefore, for the purposes of this monograph, when we discuss children in the design process we will generally be referring to children aged 6 to 12. When we discuss adult design processes we are referring to processes involving design partners above the age of 18. Children have views and developmental

needs that are different from those of adults. Techniques for working with children on design teams thus need to be specific to the needs of children. This concept will be expanded later in this monograph.

We will also not directly address design processes intended specifically for teenagers aged 13 to 18 in this monograph. Design for teenagers is a nascent field. As noted by Yarosh et al. [124], teenagers are a population with whom, to date, not much work has been done in the area of participatory design. This is changing, with recent work by Iversen and Smith [63] and a workshop to explore the space of teenagers in design at NordiCHI [95] and at CHI [94]. Adolescents significantly differ enough from children developmentally that design with teenagers should be considered separately from that of children, and thus, teenagers are not included in this monograph.

1.1.2 Technology Design Process

The phrase “technology design process” will be used repeatedly throughout this monograph. The phrase is deceptively simple, but involves two major concepts that must be examined separately — “technology” and “design process”.

In the twenty-first century, we all assume that we know what “technology” is. But if we stop to consider this concept, a concrete definition becomes elusive. A dictionary definition for technology is “a method, process, etc. for handling a specific technical problem” [2]. A similar definition applied to technology in an educational context is that technology is a “. . . systematic application of behavioral and physical sciences concepts and other knowledge to the solution of problems” [43]. These definitions have much in common; for example, they refer to solving a problem. In the case of technology created for children, the problem might be that children need support in storytelling, or a better way to learn environmental science. Another characteristic of both of these definitions is that they are not specific. Technology is not necessarily defined only by a traditional personal computer with a keyboard and monitor — it can be much more. In fact, Weiser [123] discussed technology that blended into a person’s environment. Technology might refer to traditional mouse, screen, and

keyboard for computer and software [101], media for television [38], Internet websites [5], tangible and mobile technology such as technologically enhanced stuffed animals [46], or tablet computers enhanced to help children on field trips [23].

Ubiquitous technology which blends seamlessly into the environment is becoming more common today, especially for today's children. The technologies that we focus on in this monograph are mainly digital in nature; however, the design processes used for these technologies could also apply to non-digital technologies such as paper books or writing supplies, which also fit our definition of technology.

Technologies can be created in a variety of settings by a variety of people. Technologies for children are developed commercially by companies such as Microsoft [110] or Philips [87], with government-funded agencies such as public television [4] and in academic settings, especially at universities with large HCI communities such as University of Maryland, Carnegie Mellon, Georgia Tech, and others [19, 23, 47]. Regardless of the types of technologies or the places where they are developed, all technologies must be created through some kind of process, and therefore all of them have the potential for including children as a part of the design team.

In the field of technology, the phrase “design process” may at first cause some confusion. It is necessary to distinguish between a “design process” and a “development process”. For the purposes of this monograph, a design process refers to the steps necessary to conceive and develop a technology including defining the problem, researching it, creating multiple solutions, evaluating solutions, reflecting on the lessons learned, and repeating any part of the process to refine the product. When we refer to design process we are not talking about the manufacturing or the mass production of the final product; we are speaking strictly of the process of conceiving and specifying the form and function of the technology. Because of the importance of the design process in this monograph, we elaborate more on these stages or goals in the Section 2. Others may define design process differently, such as the work between the time of requirements gathering and implementation [97]. We accept the validity of this definition and the authors of [97] accept that other definitions of design process, such as the one employed here,

are also valid. The definition used for this monograph is intentionally broad enough to encompass what we believe are all phases of the design process.

The phrase “design process” is chosen for this research as opposed to “development process” for clarity. In the field of computer science, “development” has many other connotations, including coding or programming of software. In addition, “development” in the educational sense is often used to refer to a child’s gains in cognitive, social, emotional, and motor domains. Therefore, to reduce confusion, the term “design process” will be used instead of “development process”.

Thus, combining the definitions of “technology” and “design process”, a definition of “technology design process” can be reached: a technology design process is all of the work done from beginning to end in the creation of new problem-solving tools, which can range from creating software for a personal computer to designing physical technologies such as robots. This monograph focuses on methods and techniques employed when creating technology for children, especially those that involve children throughout the entirety of the design process.

1.1.3 Method vs. Technique

It is important for the purposes of this monograph to distinguish between how we use the terms *method* and *technique* in regard to designing technology. We define *technique* narrowly. A technique is defined as an activity that a design team participates in while creating a technology. The application of a technique can be very brief and may last in terms of duration a fraction of a single design session to two or more design sessions. We refer to these applications as *design activities*. Walsh et al. [122, p. 2893] define a technique as “a creative endeavor that is meant to communicate design ideas and system requirements to a larger group”. Examples of techniques include brainstorming using art supplies, or critiquing technology using sticky notes. We define a *method*, on the other hand, quite broadly. We again employ Walsh et al.’s [122, p. 2893] definition of a method, which is a “collection of techniques used in conjunction with a larger design philosophy”. Thus, a method includes the overall philosophy of a design team. It refers to

the overall system that a team uses to design technology. A method can include one or many techniques, but it is more than a collection of techniques that makes up a method. It includes the attitude and values that the team brings to designing technology.

In Section 2, we present a general model of the design process with its accompanying goals. We use this to provide context to the subsequent sections. After discussing the design process and goals, in Section 3 we survey how designers have historically worked with users in technology design processes. Section 4 presents various design methods for working with children in the design process. Section 5 addresses the specifics on how and when to employ various design techniques. In Section 6, we revisit the underlying dimensions of child involvement and we conclude, in Section 7, by summarizing our vision for the future of designing technologies with and for children.

2

Design Process and Goals

In the previous section, we briefly defined “technology design process.” Here we give an overview of the general design process and goals which we use to provide context for the literature as to how children have been involved in the process, as well as the methods and techniques used to develop technologies with children.

There are many models for conceptualizing the design process. There are spiral approaches where a process is conducted iteratively to refine a product. There is a funnel approach which starts with several ideas which are systematically pared down through decisions made at prototype and evaluation steps until there is a single product at the end. Some researchers describe design in terms of a problem solving process. Several conceptualizations of the design process utilize different terminology. For our discussion, we will focus on a general conceptualization that includes the following design stages or goals: defining the problem, researching the problem, creating multiple solutions, evaluating solutions, reflecting on outcomes, and repeating the process (see Figure 2.1). These components are not necessarily linear, but can happen simultaneously, in various orders, and can be repeated. Most of the design methods addressed later include most of

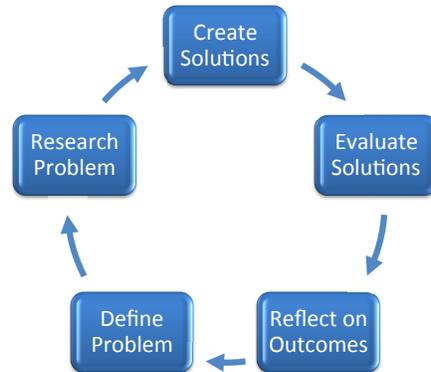


Fig. 2.1 Design process and goals.

these components or goals. Later, in our discussions of techniques we identify which design goal is best met by each technique, but first we briefly discuss each of these design goals.

2.1 Define the Problem

The first step in designing a solution is to identify and define the problem. Within the field of HCI the problem to be solved is typically to allow a user — which in this context is a child — to complete a task or somehow fulfill a need that either was previously undoable or that users would like to complete more effectively or efficiently. This often is characterized by identifying and clarifying relevant issues and defining the intended scope of the problem. In the HCI field, the solution most often includes technology. While this step may seem obvious or very basic in nature, oftentimes, the user needs are not clearly stated a priori which requires designers to revisit the problem definition even as they are designing several possible solutions.

2.2 Research the Problem — Gather Requirements

When addressing a defined — or even semi-defined — problem, designers first seek to understand the problem better and to gather requirements that the final design will need to meet. Requirements gathering can be either a passive or an active process. Designers can

research what has been done in the past, they can observe people, in this case children, in the situation for which a solution is needed, or they may observe users interact with the prototypes of the product to be designed or of technology that currently purports to solve the identified problem. Researchers may gather requirements more directly and interactively from those who will use the product through direct questioning and interactions with intended users. In all, the requirements gathering process provides insights and a concretization of necessary and desired features, purposes, and characteristics.

2.3 Create Multiple Solutions (Brainstorming)

Ideation or brainstorming is a broad term used to describe the generation of many ideas to solve a problem. In the design process, brainstorming generally takes place very early in the process, when solutions to problems are first being discussed, and “Blue-sky” ideas are possible. At the brainstorming stage, ideas do not have to be realistic or feasible. Brainstorming sessions are designed to encourage a free flow of ideas out of which may grow the next great innovation. In this phase, models and prototypes can be made. The artifacts generated and fabricated at this stage are intended to be representative of key concepts and ideas the technology will embody.

2.4 Evaluate Solutions

At various stages in the design process, products can be evaluated to form the direction of the design or to provide a final assessment about the product. There are many ways of evaluating a prototype or product, some of these include: prototype walkthroughs, sticky noting, surveys, focus groups, and field or lab studies. The outcome of an evaluation can include what is good, what is bad, and what should be changed about a possible solution. An evaluation can include quantitative and/or qualitative investigations into the effectiveness or utility of a proposed solution. It can be used to weigh relative advantages and disadvantages of multiple solutions.

Although evaluating is often thought of as the end stage of design, evaluation should be a continual part of the iterative process. Technology should be evaluated throughout the design cycle in order to create the strongest product possible. Evaluations early in the design cycle can be formative, to provide input into the technology, or predictive, in which case evaluations are done on ideas rather than prototypes [98, 99]. Often, formative evaluations are quite informal in nature, as they are meant to guide the continuing design process rather than to provide empirical evidence about the usability of a final product. Summative evaluations come after a technology has been designed and released, and would typically be carried out by children in the role of user or tester. As summative evaluations come after the design process is completed, they are beyond the scope of this monograph.

2.5 Reflect Outcomes, Repeat/Iterate the Design

After completing each of these stages or goals, it is important to critically reflect on the outcomes of the evaluations, to perhaps re-evaluate the problem, as well as to identify what steps need to be repeated. For example, if gathering requirements uncovers an element that was not included in the original problem description it may be necessary to redefine the problem. Or, if during the evaluation of a design solution a particular weakness emerges, the team could ideate specifically about that weakness and work through various other design goals to address that weakness. Again, it is important to recognize that each of these goals or stages in the design process are not mutually exclusive and are not linear — designers rarely progress from one goal to the next in a sequential manner to achieve a final product.

2.6 Design Process and Goals Summary

The overall design process and goals include defining a problem, researching a problem, creating multiple solutions, evaluating those solutions, reflecting on what has been learned, and repeating any necessary steps in order to continually refine the final product. Depending

on the stage in the design process, or the desired outcomes from a design session, designers may choose to use different techniques. We have simplified the design process to these five goals to provide a context for discussion as we present a brief literature survey, and methods and techniques used to involve children in the design process.

3

Brief Literature Survey: Involving Users in the Design Process

In this section, we review relevant literature which focuses on involving users in the design process. We begin with a discussion of how researchers have worked with adult users as participants, as this was the predecessor to involving children in technology design processes. Next, we motivate why children need to be thought of differently from adults in regard to involvement in design processes. We then present a discussion of how children have been involved in technology design processes, and conclude this section with a discussion about why it is important to co-design with children.

3.1 How Have Adult Users Been Involved in the Technology Design Process?

Involving end users, or the people who will eventually use the technology, in the design process is the purpose of user-centered design (UCD). UCD is a general philosophy that encompasses several approaches, methods and techniques, but the principal component is that users are involved at some point in the process [1]. Users' involvement can range anywhere from gathering user requirements to usability testing

to involving users in the design process. We briefly present just two of the major UCD methods below: Participatory Design and Contextual Inquiry and Design. Both Participatory Design and Contextual Inquiry and Design were developed to give adult users a voice in the design of technologies for adults. Their inclusion here is due to their eventual use as a foundation for technology co-design with children.

3.1.1 Participatory Design

Participatory Design (PD) — as its name implies — allows end users to have a voice in the design process. It began decades ago in Europe, primarily in Scandinavian countries [39]. Trade unions in Sweden were strong enough to demand that worker’ voices be heard in shaping their work environments and the technologies that were a part of those workplaces [16, 17]. Because of its worker-based beginnings, this movement is often referred to as the workplace democracy movement [85], as is evidenced by the title of one of the early articles describing its practice: “Computers and democracy: A Scandinavian challenge” [16]. PD views were subsequently shared in ACM conferences including Computer Supported Cooperative Work (CSCW) and the Conference on Human Factors in Computing Systems (CHI), in the early 1990s which fueled the proliferation of this approach in the United States [85].

While in PD the voice of the people is heard in a somewhat democratic fashion, the goal is compromise, not consensus [73]. PD focuses on developing cooperative strategies for system design [107]. It gives workers in the environment (i.e., system end users) a voice in the design process. Some of the techniques used in PD include interactive experimentation, modeling, testing, hands-on designing, and learning by doing [20]. Low-tech prototypes can be drawn and created on blackboards, index cards, and paper. Through these techniques adult system users communicate with system designers and developers the requirements for the system.

PD encompasses a large field of research and is the basis for many of the co-design methods employed for adults and children. Muller and Kuhn [85] suggest PD can be viewed as being mapped onto two dimensions: first a dimension of “Who Participates with Whom in What”;

and second, “Position of Activity in the Development Cycle or Iteration”. The first dimension ranges from designers participating in the user’s world to users directly participating in design activities. The second dimension ranges from early to late in the design process.

While PD had very specific beginnings, the techniques of PD have been built upon and expanded in other methods, including those intended to include children in the design process, such as Bonded Design, and Cooperative Inquiry. These methods have the focus of giving users a voice in the design process — not just as users, but in some cases as co-designers. This is the case with many of the more recently developed methods for designing technologies with and for children.

3.1.2 Contextual Inquiry and Design

Beyer and Holtzblatt [14, 15] pioneered Contextual Design, a method which puts the technology end user at the center of the design of new technologies not only at the end of the process, but also during the process. Contextual Design emerged from incorporating adult employee needs into the design of flow and technologies to improve the work process.

Contextual Design consists of a set of steps or processes which inform and direct the design team. These steps include: collecting data (Contextual Inquiry), interpretation of the data, data consolidation, visioning, storyboarding, user environment design, and prototyping. In Contextual Inquiry, the user is involved in collecting the data and prototyping steps. During the data-collection step designers observe and gather information while workers go about their routine processes. The workers or users are observed within the natural context of the process that is to be re-designed. Not only do the designers observe workers, but they can also engage them and follow up their observations with interviews. Thus Contextual Inquiry is a form of UCD where design team members gather interview information from users of the system while the users are in the context of their work tasks while using the current system. The gathered information is then analyzed by the designers in the interpretation phase to discover user routines or processes. Designers use the gathered information to create and describe the different

work models: flow, sequence, cultural, artifact, and physical. In the data consolidation phase, individual user data is grouped and combined in a hierarchy that further describes the full process to facilitate the creation of representative personas of the new system. Through visioning and storyboarding the team captures the user work practice and creates scenarios of how users will work with the new system. This enables system requirements to be established. A prototype — paper or more sophisticated — is created which can then be put back into the hands of the users in the native environment of its use to further the design and development of the new system. Typically users pretend to do their regular tasks using the prototype and the users are interviewed during and after using the prototype system. Prototype revisions, user walkthroughs, and interviews can be done up to three times to refine the requirements for the new system. While Contextual Design is generally utilized for adults its “use of low-tech prototypes, pictorial diagramming, and concrete techniques lends itself to work with children” [73].

3.2 How is Designing for Children Different from Designing for Adults?

Many of the current methods and techniques for designing with children grew out of or built on ideas from Participatory Design and Contextual Inquiry and Design as developed for use with adults. As discussed earlier, Participatory Design and Contextual Inquiry and Design are two forms of UCD focused on adult technology users becoming involved in technology design. These methods provide some of the background for design partnering methods with children. These methods have been adapted and others created to enable working with children during the technology design process. While there are many similarities in co-design involving only adults and co-design for adults and children, there are also some considerations for modifications when children become a part of a co-design process as is discussed later when we address methods and techniques for designing with and for children.

3.2.1 Similarities in Adult and Child Participatory Design

There are many similarities between adult and child methods of PD. To begin, whether the participant is a child or an adult, they are providing specific expertise. While adults are experts in their field, such as the unique skill-set a factory worker in Scandinavia has, children are experts at being children. While all adult designers were once children, our memories fail us and we cannot possibly hope to remember all of the nuances of what it means to be a child. Additionally, even if we could entirely recall our childhood experiences, we are not children in today's world. We do not know what it means to grow up knowing that mom always has a phone in her pocket, or assuming that every screen is a touch screen. Childhood has changed and will continue to change [27]. The only way that we can keep up with it as designers is to include children in our design processes. As unique as the Scandinavian factory worker's skill-set is, so too is a child's in relation to being a child.

Additionally, children may undertake many of the same design activities as adults within the context of a design process; for example, both adult and child co-designers may be asked to brainstorm, prototype, or evaluate. However, as we discuss in the next section, how these activities occur may need to change for children to be optimally included in the design process.

3.2.2 Modifications Needed for Children to Participate in Co-Design

Developmental differences between children and adults necessitate different methods of design when working with children rather than working with adult users. For years, developmental experts have researched the ways in which children are different from adults, and how child development progresses over time [90, 116]. We should apply this knowledge of child development both in the technologies that we design [42] and how we interact with children in technology design processes. Due to developmental differences, children need different supports and scaffolds in order to accomplish design activities than adults do. Many of the changes that need to be made to adult-centered participatory

design methods in order for them to work with children stem from the very different developmental abilities that children have from adults. Children have different cognitive, motor, social, emotional, and communication abilities than adults [13, 75]. The difference in each of these domains must be considered when undertaking participatory design with children. The cognitive level of a child may mean that she needs abstract concepts to be explained in a more concrete manner [75, 91]. A child's motor development may mean that he needs to work with an adult design partner in order to complete the fine detail on a low-tech prototype. Socially, children may need help adjusting to working in small, ever-changing teams. Emotionally, children may need support in understanding that although their individual ideas are not immediately apparent in a final product, they nonetheless contributed to the design of that product and can feel pride in their contribution. Children may need support in communication — whether from an adult who helps them remember what to say when presenting an idea, or from an adult who helps them to write design ideas in a journal. Additionally, children of varying ages have different developmental abilities. It is therefore important to consider not only that children are children, but moreover the ages of the children that are participating on a team.

There are issues that deal with the realities of simply being a child. Children need more breaks than adults do. Their attention spans are shorter and in order to get good ideas, adults need to ensure that adequate breaks are provided. Children also may become upset more easily than adults, or may tire more quickly during a design session. All of these should be monitored by caring adults during design sessions. Although many of these accommodations may seem negative in nature, the unique developmental level of children is also beneficial. Sometimes children can be more open to more radical ideas than adults. They may be more open and flexible in their cognition than adults, and thus may contribute more creative ideas.

Children and adults may undertake similar activities during the design process; however, they may need to be modified for use with children. For example, in their respective design processes both adults and children may brainstorm new blue-sky ideas and critique current technologies or prototypes during the design process. Designers might

ask a group of adults to brainstorm ideas without much further explanation; however, children may need an explanation of what brainstorming means, as well as support in undertaking the process. When children are new to design partnering, they may not have had practice brainstorming, and may not have exposure to what the concept means. They also may need to be reassured that the adult design partners legitimately value their ideas in a brainstorming session, and are not just looking for one correct answer. Children may also need positive reinforcement at more regular intervals than adults to continue in their work. This example illustrates not only the support that children need cognitively, such as help understanding what brainstorming is, but also socially and emotionally, through positive reinforcement.

When adults work with one another, generally they work with one another as peers. While it is true there are administrative hierarchies that exist within an adult workplace, the power structure is inherently different than that between children and adults. When children and adults work together the traditional paradigm is that the adults have all of the power — adults say or define what is appropriate, correct, or necessary. Children are generally expected to follow the lead and direction from adults. For collaboration and elaboration to occur between children and adults on a technology design team, this pre-supposed power structure needs to be addressed so that each can — in a more uninhibited fashion — communicate and share their ideas within an environment of trust and collegiality. Techniques for equalizing power will be further discussed later in sections on specific design methods.

The modifications needed for children to participate in co-design teams are largely based on the developmental levels of children, as well as social structures. In the next section, we discuss the ways in which children have been involved in technology design processes.

3.3 How Have Children Been Involved in the Design Process?

Through broadened use of Contextual Design and Inquiry and in PD for adults, in the past few decades the notion of including end users

in a form of UCD has become more established as a norm. As more technologies were developed for children, the need for a form of UCD for children became apparent. A review of technology design processes that involve children reveals many roles that children can, and have filled over the past 40 years in the design of technology intended to be used by them. In the following sections we discuss these roles.

3.3.1 Overview of Roles and Dimensions of Children in Technology Design Processes

In her article “The role of children in the design of new technology” [29], Druin outlines many ways in which children can participate in the technology design process and sets forth a continuum from least to most involvement from *users* to *testers* to *informants* to *design partners* (see Figure 3.1). As indicated in the figure, as one moves along the continuum, the roles encompass those at a less involved level. Thus, a tester can perform the roles of both tester and user, where a design partner can perform all the roles. While a design partner can migrate among the different roles throughout the design process, when a technology is created, any validation evaluation should be conducted with a different group of users — in this case children.

The least involved, but most historically long-standing role is child as *user*. Users interact with technology only after it is completed and marketed. Next along the continuum are *testers*, who also have limited input in the design process, but are allowed to interact with technology before its completion and large-scale deployment. As *informants*, children are much more involved in offering opinions on the design of

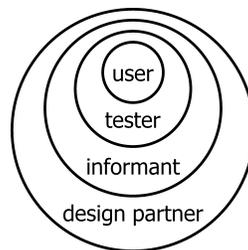


Fig. 3.1 Roles children can play in the technology design process [29].

technology and are involved in the design process at various points, when researchers feel that children's input is necessary. Finally, the most involved role that children can play in the design process is as *design partners*, who are active participants and equal stakeholders throughout the design process. These roles will be further explained in the next section. Drawing from our discussion above of adult design processes, PD for adults is similar to informant and design partnering for children.

Another perspective of the differences between roles can be expressed in terms of the general design process sub-goals previously discussed (see Section 2). In terms of design goals, users are generally involved in helping to define or research the problem as well as evaluation; testers assist in evaluating solutions and reflecting on outcomes; and informants or design partners can be involved in all aspects of the design process, with an emphasis on helping to create solutions.

Druin [29] also describes three dimensions which underlie all of the roles (see Figure 3.2). Considering the location of a technology design project along these dimensions may help researchers to choose the role that children might best play in the design process. First is the dimension describing the *relationship between the users and the developers* of

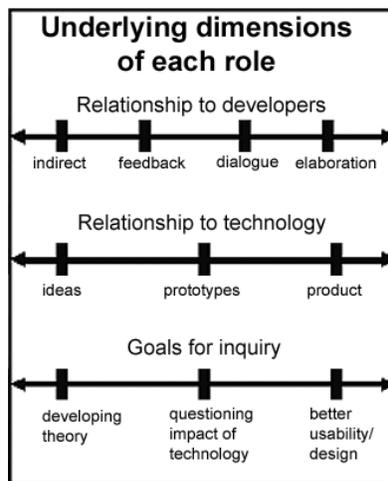


Fig. 3.2 Underlying dimensions of children's involvement in the technology design process.

the new system. This relationship can be indirect (e.g., making a choice to purchase or not the system), feedback (e.g., user testing before a release), dialogue (e.g., informing the design at key points), or elaboration (e.g., being a part of the design team). As the involvement along this continuum becomes more intense, so too would be the role that the child would play as a part of the technology design process. The second dimension is the *relationship to the technology* that can range from ideas to prototypes to fully developed products. In this dimension, designers need to consider when they will include children and what types of artifacts they will make. The last dimension is the *goals for inquiry* which could be developing theory, questioning the impact of the design, or probing ways to better the design or usability of the system. While some designers may be interested mainly in commercial design, development, and deployment of new children's technology, others may be more academically interested in developing theory or studying impact. The location along this continuum for a particular project may help determine the role that children should play in that inquiry process. For example, if you want to develop theories and question the impact of technology you may use more observational techniques that are more typical when involving children as users or testers.

Table 3.1 shows the relationship between the roles children can play in the design of technology to the underlying values described in Figure 3.2. As this table illustrates, there is more than simply a quantitative difference in how much time children are involved in design processes as the continuum moves from user to design partner. The underlying goals each role encompasses leads to rich qualitative differences between each role.

3.3.1.1 User

Child *users* are the least involved in the technology design process, but they are most long-standing in history and it is the most common role that children play in the technology design process. Children participating as users interact with technology only after it is completed and marketed. Children have been involved as users in the technology design process since the 1970s. The first HCI paper regarding children

Table 3.1. A comparison of the three dimensions for the roles children can fill in the design process.

Dimensions/values	Role of child			
	User	Tester	Informant	Design partner
Relationship to developers (adults)				
Indirect	X	X	X	X
Feedback		X	X	X
Dialogue			X	X
Elaborate				X
Relationship to technology				
Ideas			X	X
Prototype		X	X	X
Product	X		X	X
Goals for inquiry				
Developing theory	X	X		
Question impact of technology	X	X	X	
Better usability/design		X	X	X

as users was published by Malone in 1982 [76]. Children who are users are helping to understand how a technology that exists today is being used. Adult researchers typically observe child users to look for patterns of activity and general use. Adults then abstract from their observations what they believe should be changed in the technology. A child user is typically not asked for an opinion of a technology, rather the adult user interprets what that might be from observations.

3.3.1.2 Tester

Next along the continuum are *testers*, who also have limited input in the design process, but are allowed to interact with technology before its completion. This role was first used with technology such as Logo, Smalltalk, and Basic. When working with children as testers, adult designers, upon observation, will make changes to the technology before its final inception. The role of tester is the first role in which children are brought into an iterative process. This role became common practice in the early 1990s [29]. The way in which the child interacts with the technology as interpreted by adult researchers is still the focus when children are testers.

3.3.1.3 Informant

There is a qualitative shift in the type of interaction and level of involvement that children assume in the design process beginning at the informant level. As *informants*, children are much more involved in offering opinions on the design of technology. They are no longer called on solely at the end of the process, but rather are involved in the design process at various points, when researchers feel they will be informative. Thus, the informant role goes beyond a simple interview of a child. It includes not only having a dialogue about a product, but also the child actively participating in design activities. For example, adult designers may decide that they need to work with children to brainstorm ideas, or further along in the process they may want critical input from children on a prototype.

The power of informant design is that the adult designers can determine when in the process they feel that the input of children is most needed. This is also the first role in which children are more directly asked for input on technology, rather than simply observed in their interaction with it. In this way, informant design differs from ethnographies in that children are both asked their opinions and asked to contribute to the creation of the technology. When children are informants, adult researchers can clarify intentions, thoughts, and ideas rather than just interpret meaning from observations and feedback from children. There is an interactive dialog between the children and adults when working in informant design. Many researchers, including Scaife and Rogers [102] and Scaife et al. [103] advocate informant design as an effective way to design technology for young children. Informant design came to prominence in the mid-1990s.

3.3.1.4 Design partner

The most involved in the design process are children as *design partners*. These children are active participants and equal stakeholders in the design process throughout the process [29], differing from informants in the amount that they are involved and the ways in which they interact with adults on the team. Design partnering refers to a specific level and type of involvement that children can have in the technology design

process. It is a kind of involvement where children become equal team members and stakeholders with adults in the design of new technologies. Typical power structures between adults and children are broken down as adults and children work as teammates in technology design. A child design partner participates in the entire design process [29]. Design partnering has become more prevalent in the 2000s.

3.3.2 Other Ways Children Participate in Design

Recently, new types of design have emerged which do not fit neatly into the schema above; these include bonded design, children as software designers, and designing for diverse children.

3.3.2.1 Bonded design

Bonded Design [73, 74] is a design process that falls between *informant design* and *design partnering*. Children participate for a short-term but intensive time in the design process, for example twice a week for six weeks, participating in activities such as those informants or design partners would. Children working in Bonded Design may work with researchers in school settings. The “bond” in Bonded Design refers to the bond between the children and adults on the design team.

3.3.2.2 Children as software designers

Another way that children can participate in the design of new technology is that children can be software designers. This process is advocated by Kafai [65, 66, 67]. Using this model of the design process, children become software designers and developers; adults are not involved in the process other than to teach children the technological skills, such as programming, that the children require to carry on the process [66]. Again, this type of involvement differs greatly from being a design partner — as the name implies, a design partner has partners in the design process — both adults and peers. When children act as software designers, children are either working alone or with peers only, not with adults. Additionally, initially the software these child software designers created was not intended to become products for a larger audience as

they were primarily made for an educational purpose. This differs from the technologies designed by children in the roles of user, tester, informant, design partner, or bonded design team member as these technologies are generally intended for wider distribution. More recently, environments and sharing portals like Scratch (<http://scratch.mit.edu/>) have been developed to make the programs developed by children publicly available; however again, the primary purpose of Scratch is to educate children and the public portal is intended to be a learning community to support this educational purpose.

3.3.2.3 Designing with and for children with special needs

Recently, technology design for children with special needs has come more to the forefront of the HCI field. While technology for children with special needs has been developed for a number of years, designers now may consider not only what kind of technology to design for children with special needs, but also how to involve children with special needs in the design process.

The kinds of special needs that children involved in a technology design process may have can vary greatly. Some of the children with special needs who have been involved with designing technologies include those in sterile hospital settings [112], children with severe motor impairments living in assisted living [59], children who are blind or visually impaired [78], children with physical or learning disabilities [18], and children who are deaf or have hearing issues [56, 62], children who are on the autistic spectrum [8, 89], and children with behavioral issues [45, 64, 77].

Children with disabilities can be involved as design partners [45, 54, 59, 62, 64, 78] and informants [18, 56, 77, 112]. This suggests an in-depth amount of involvement in technology design is possible for children with special needs. In design work with children with autism, Parés et al. [89] employed children with autism as testers, and Barry and Pitt [8] discussed the design process, but did not include children with autism in their process. More recently, researchers have been considering involving children with autism in much more in-depth ways, with more researchers adapting methods in order to design for children

with autism [80]. Researchers have begun to consider that PD may be even more important in designing for children with disabilities, as non-disabled designers do not fully understand what it is to experience the world with a disability [40], and thus the input of children with disabilities may be even more important. New methods and techniques of designing involving children with autism have been created and used recently in designing technology with and for children with autism. These methods include the IDEAS framework [11, 12] and ECHOES [41] which is a technique and tool created to allow autistic children to give critical feedback on technology in the context of participatory design sessions.

Guha et al. [54] suggest an inclusionary model for involving children with special needs as design partners in the technology design process. In this model, the authors suggest that it is possible to design involving children with disabilities as full design partners as long as the researchers take into account both the nature and severity of the child's disability as well as the availability and intensity of support available to the child.

There are also cases in which authors make mention of designing involving children with disabilities, but ultimately decide that this process is too cumbersome. In one case designing a communicative technology for children with autism, the children were excluded from the design process due to "communication barriers", and their teachers were instead used as proxies in the design process [25]. In another study [93], researchers did not include people with disabilities in their process due to "time and resource constraints" and instead worked with other children as design partners. This information leads one to believe that children with disabilities can be involved in the design process; however, as their disability becomes more severe (e.g., severe autism), they are less likely to be included in the process in an in-depth manner.

3.4 Why Co-Design with Children?

We have provided a brief overview of how children have been involved in the design of technologies intended for them. The focus of this monograph is on methods and techniques of co-design with children.

In our own work, we employ such a PD method with children; thus, we feel it is important to explain and share why we strongly believe in co-design methods with children. Our reasons are twofold: first, we find that by co-designing with children, we come up with more — and more varied — ideas and technologies than we ever would without children; and second, we believe in giving power to marginalized groups, which children often are.

Over the years of designing with children, we have found that children offer honest feedback, as well as ideas and technology directions that we would not have come up with as adults working without children [29]. Our own work in co-designing with children has led to innovative and groundbreaking technology for children including the International Children’s Digital Library (ICDL, www.childrenslibrary.org), an extensive, online, multilingual library of children’s literature available free of charge. From conception through iteration, all parts of this technology were created working with children as co-designers. While we cannot say that we would not have made an interesting technology without child co-designers, we can say that throughout the design process, the children came up with creative and innovative ideas that we would not have had on our own without the children. This is true for countless other technologies created through co-design, including StoryKit [9], a mobile application which supports children in storytelling, Mobile Stories which supports collaborative narratives [35, 36], Tangible Flags which enables outdoor collaborations [21, 22, 23], and StoryRoom, an indoor physical programming environment [3, 81].

Additionally, as with the original movement in PD that was intended to empower workers in Scandanavia, we believe that co-design with children empowers children. That PD movement supported the inherent right to have a say in the design of the environment in which one lives. Co-design with children extends this notion to children. Seymour Papert supported the notion that empowering children politically and intellectually has existed for quite some time, even before computers existed [88]. By allowing them a voice in the design of their technology, we are continuing to support this empowerment. Empowerment as an experience of co-design has been supported in literature [50].

Thus, our belief is that co-design methods not only produce creative, varied, and unique technologies that would not exist without children's participation in the design process, but also that the design process empowers children. For these reasons, we design technology using co-design methods. The remainder of this monograph presents methods and techniques for involving children in the design process primarily as informants or design partners.

4

Methods of Designing with Children

In this section, we present several methods of designing with and for children. These methods include: Bluebells, Bonded Design, Distributed Co-Design, Cooperative Inquiry, and Children as Software Designers. Table 4.1 summarizes the primary ages for which these methods have been used. We describe each of these methods further in the subsections that follow in the order of least to most involvement of the children in the design process. These methods were chosen as they are expressly intended as technology design methods. Other methods, such as interviews and field deployments, are often used within a design process; however, they are not methods specific only to design process. The methods reviewed here are specifically intended as technology design methods. We first address some methods that are mindful of children, and then we address methods that involve users in a more integral manner as informants or design partners.

4.1 Design Approaches that are Mindful of Children

The design methods we will focus on later involve children in some type of direct manner during the design process. While not the focus

Table 4.1. Design methods and the ages of children who have participated in these methods.

Method/brief description	Ages*
Learner Centered Design Method and paradigm where the design focus is the learner	Not specified
Personas “Fictional children” that are detailed written conceptions of the eventual users whom designers continually reference throughout the design process	8–12
Bluebells Sequential process where adults meet, then observe children, then meet again. Includes activities broken into three design phases: before, during, and after play	7–9
Bonded Design Children participate for a short-term but intensive time (e.g., twice a week for six weeks) participating in activities and utilizing techniques such as those that used by informants or design partners	11–12
Distributed Co-Design Children and adults separated by time and space work together in the design process	7–11
Cooperative Inquiry Children and adults work together as partners throughout the design process in a collaborative and elaborative manner; cooperative inquiry teams are characterized by having a long-term relationship that spans across projects	5–14; most often 7–11
Children as Software Designers Children design software using tools designed for them	8–12

*Ages listed in the table are the ages of children who have participated in this design method as found in the literature.

of this monograph, we feel it important to describe two other design methods that, while they do not necessarily directly involve children in the process, they are mindful of children. These two methods are Learner-Centered Design and Child-Personas.

4.1.1 Learner-Centered Design

In the mid-1990s, Soloway et al. [108, 109] challenged the notion that the ideal manner of thinking for designers and HCI professionals was to think about *users* at the center of design, but rather designers should think about *learners* at the center of design. Thus, they created

Learner-Centered Design as a way to augment UCD [109]. In the design concept of Learner-Centered Design, the end user is thought of as a learner — whether they are a traditional student or a professional. Although no age range is specified in employing Learner-Centered Design, it is easy to imagine that one could apply this philosophy to learners of very diverse ages.

As a result of this philosophy, Soloway et al. [109] incorporated some of the ideas of Vygotsky into the Learner-Centered Design process, which led them to build science software which incorporated a variety of scaffolding or support for the participant. Learner-Centered Design also takes into account the context in which the technology will be used [118]. Learner-Centered Design considers all end users as learner, but does not include these user-learners as a part of the design process.

4.1.2 **Child-Personas**

Creating Child-Personas is a method which can be used when a design team would like to work with children in the design process, but logistical issues make working with actual children impossible, or very limited in nature. There may be insufficient time or financial issues that prohibit working with children as design partners for the duration of a project. In other situations, university or workplace regulations including policy restrictions may restrict a team's ability to work with real children [7]. When a team which is designing for children cannot work directly with children, there is a danger that they will incorrectly conceptualize who the child user is [6]. This may result from many reasons including possibly a lack of interaction with children, or seeing children through adult eyes. Designers in this situation can fall into the trap of being self-referential and emotional in thinking of the child for whom they are designing.

There has been significant work done on developing and using adult personas in design work [24]. Antle [7] has modified the work on creating adult personas to be appropriate for creating “child-personas”, which are more developmentally based than adult personas, which tend to be more task-driven, that is, adult personas tend to focus on the task that

the adult will need to perform with the completed technology [6]. Much of the work in child-personas has been done for children aged 8 to 12. The basic idea behind child-personas is to create “fictional children” whom designers continually reference throughout the design process. These fictional children are detailed conceptions of the eventual users of the technology. Most often, child-personas do not focus on tasks but rather on children themselves.

Using Antle’s child-persona framework, during the process of creating personas, researchers should consider childhood needs (i.e., what are the basic needs that all children have), developmental abilities (i.e., what is generally the developmental level of children in the target age range), and experiential goals (i.e., what is the experience that children might have with the technology). While childhood needs and developmental abilities can generally be taken from project to project, the dimension of experiential goals needs to be revisited for each specific project.

Before beginning to create the child-personas, researchers should collect information about the target audience through a variety of sources, including literature reviews and real-life experiences with children such as interviews and observations, and through market research. Personas are most helpful when they are very detailed. Long narrative descriptions, including not only the demographics of a persona, but also the fictional child’s environment, likes and dislikes, extracurricular activities, and even favorite food should be included. Good personas should be based on items such as the team’s experiences with children, observations of the target population, analysis of artifacts created by children, and developmental literature about the children. Best practices indicate avoiding too much overlap in personas, and using the smallest number of fictional children possible. A detailed procedure for creating child-personas can be found in [7].

Once the personas have been created, they should be referenced frequently throughout the design process. Throughout the design process, designers should think about and refer to the personas — what they would think or feel about the product which is being designed. In order to achieve the best design, team members should think about personas

as real people who are simply not present. They are examples of the users who will ultimately benefit from the product.

Personas can also be introduced to child informants or testers during development, and the informants or testers can validate the personas and also refer to the personas as they test or design the new technology. While in most cases teams working with personas do not work with actual children in their design process, personas can be used to supplement working with children as informants or testers. In any case, child-personas should be validated with real children [6]. Should a team lack the necessary resources to work with children as design partners, personas can be referenced during the time of the design process when real children are not able to be present.

While Learner-Centered Design and Child Personas are methods which take the needs and opinions of children into the design process throughout the design process, they do so without actually including children in the design process. We now move on to a discussion of methods which include children during the design process.

4.2 Bluebells

Bluebells borrows from both child-centered design and expert design. Set forth by Kelly et al. [68] and working with children aged 7 to 9 years old, Bluebells is based on British playground games. It includes activities broken into three design phases: before, during, and after play. In this method, children participate mainly in the design activities in the *during* play stage. Adults design in the *before* and *after* stages without the children. This pattern of working together, that of adults working together, followed by children working together, and culminated by the adults working together makes this more of a serial approach to design. While involving children in the *during play* stage, children can participate in four different activities: *I-Spy*, *Hide and Seek*, *Tig*, and *Blind Man's Bluff*. Each of these activities is named after a children's playground game. Each activity has a different purpose that directly relates to a portion of the system that is being designed. The *I-Spy* game's purpose is to gather contextual information; the

Hide and Seek game, the content for the application or product; *Tig*, the navigation and control mechanisms; and *Blind Man's Bluff* to get the look and feel of the interface. Each of these activities can be thought of as a technique within the overall Bluebells method.

The *I-Spy* game is used to get children to mentally explore the context of use of a system. Adult designers observe children as they interact within the context of the system to be created. Not only do designers observe the children, but the activity also allows children to explore the context naturally so they do not seek to identify items they think the adult designers “want” them to. In the *Hide and Seek* activity children are first asked to brainstorm words associated with the technology, then they interact with wire-frame designs, and finally they are provided with blank pieces of paper on which they can add or modify the content of the application. In *Tig*, children are given artifacts and locations or screens through which they must coordinate the navigation. Through *Tig*, the adult designers can gain insight as to the notions children have pertaining to the navigation of the system. In *Blind Man's Bluff* children are paired, one child closes his/her eyes and imagines the interface while the other child draws what is being described by the original child. This process results in a description of the physical device or product.

In the after play stage, adults discuss and analyze the artifacts and observations made during the *during play* stage of design. Adults identify underlying interaction concepts and interface structures that they will then implement in the final design. The implication is that there will likely be no direct evidence of the children's design processes (e.g., visible pieces of the artifacts created by the children) in the final result, but the children's implied interactions and structures will be evident.

Some of the techniques within the Bluebells method are conducted out of the context of the technology's intended use, so it is important to adequately contextualize the system via an introduction so that children (and adults) are prepared to perform their design work with the proper context in mind. The researchers also stress the importance of reminding children to reuse the designs they previously created, and to allow multiple forms of communication and artifact generation to ensure ideas are shared and different formats are explored.

4.3 Bonded Design

Bonded Design falls in intensity between *informant design* and *design partnering*. Bonded Design pulls from adult methods of design including Contextual Design and Participatory Design, as well as methods of design intended for use with children such as Learner-Centered Design, Informant Design, and Cooperative Inquiry. Vygotskys Zone of Proximal Development [116] is a basis for the Bonded Design method. Bonded design has been implemented primarily with children aged 11 or 12.

In *Bonded Design* [73, 74], the “bond” refers to the necessity of all partners, adult and child alike, to bond together their knowledge in the interest of innovative technology design. The children and adults are each seen to have their own expertise in coming to the technology design process, and the interdependence between children and adults on the team is appreciated and encouraged as they become a community of designers [73]. Proponents of Bonded Design believe in children working as design partners but question the true ability of children and adults to work as equal partners, and thus situate themselves between informant design and design partnering [74].

In Bonded Design, children participate for an intense short period of time, for example they may meet twice a week for six weeks. When they meet, they will participate in design activities and utilize techniques such as those that informants or design partners would, including brainstorming, exploring and critiquing existing technology, and using drawing as a technique for showing design ideas. The teams are intergenerational, including children and adults; however, the children on a given team are typically all of the same age, for example in grade three or grade six. The team usually works intensely for this short time on a single project.

Bonded Design often takes place in schools; however, school effects are ameliorated through methods such as meeting in art rooms at lunchtime, and the sessions being run in a casual manner including using first names for adults and children alike and having children not raise their hands to speak so as to not emulate a student–teacher relationship [73]. This way, the work is not taking place in the home

classroom of the teacher, nor is it during a time that is traditionally reserved for instruction. Additionally the adults on the team are researchers, not the children's teachers. The combination of these efforts helps to bring the team together in a way that alleviates some of the traditional adult/child dynamics in a school.

Bonded Design can be a good option for a design team that would like to do in-depth co-design with children, but do not have the resources in time, space, or financially to sustain an ongoing child design team. While Bonded Design affords many of the same benefits as ongoing co-design, such as in-depth input from children on technologies, there may not be as much time or as firm of a relationship as there is in an ongoing co-design team where children truly become designers and partners. Hence, it is situated between informant and design partner on the continuum of level of depth of child in design process.

4.4 Distributed Co-Design

With a globally expanding working world, there are two important issues that can impact cooperative design, namely time and space. Not all partners may be co-located when they need to design. Not being co-located can be further complicated by not being in the same time zone. If partners in New York need to work with partners in India, not only does the issue of distance need to be addressed, but also the issue of differing time zones. This phenomenon of the world flattening or becoming smaller impacts children as well. Now, through the Internet and social media, a child on the other side of the world can be a peer in the way that not long ago only the child down the street could be. Thus, as designers it is important to support this international community and develop methods and techniques to support co-design across both time and space.

There are many formats that Distributed Co-Design can take. Which one is employed depends on a variety of factors, including the resources of each group, as well as the unique characteristics of all the co-designers involved. One technique employed in Distributed Co-Design is Video-Co-Design. In this technique, each site participates

in the same Cooperative Inquiry design activity, such as low-tech prototyping. The sites are linked through videoconference, so that they can see each other and collaborate as they work. In order for Video-Co-Design to be feasible, the sites must coordinate the time to do this. This requires that times zones are similar, and that each site has videoconferencing equipment or access to a program such as Skype which allows for long-distance face-to-face collaboration.

If time zones are not similar, a distributed design team may choose to use e-CoDesign. In e-CoDesign, all distributed sites must agree on what the design activity will be ahead of time, and a timeframe in which to complete the initial design activity. Then, each distributed site does the design activity at the time of their choice. Design partners coordinate sending power point or other files to one site who will elaborate by compiling the work from all the sites. This technique requires more adult guidance to coordinate, and there is overhead in terms of time and extra coordination in order to accomplish e-CoDesign.

In e-CoDesign, after the initial design activity is done, each site adds to and edits the previous site's work, and then e-mails it on to the next group. This iterative cycle occurs until all distributed groups have worked with every other group's initial prototype. With this technique, it is harder to elaborate because there needs to be one site which compiles the work. However, unlike Video-CoDesign, eCoDesign does allow for asynchronous collaboration.

Another type of Distributed Co-Design is one that was developed at the University of Maryland, and it is the technique of Interactive Co-Design for distributed groups [120]. The idea for Interactive Co-Design was an outgrowth of the issues with Video Co-Design and eCo-Design. Interactive Co-Design allows for specialized software which supports multiple, concurrent, asynchronous layers of elaboration. Such software can be installed on each site's computers and thus can support asynchronous, distributed designing. Prototypes of the software are highly visual, and can separate each group's input. The tool that was developed at the University of Maryland that implements this type of co-design is DisCo, which has been implemented with children aged 7 to 11 years old [120]. For more information on this tool, see Section 5.6.

4.5 Cooperative Inquiry

Cooperative Inquiry was developed by Druin et al. first at the University of New Mexico and then more extensively at the University of Maryland [28, 29]. Based on design methods such as *Participatory Design* and *Contextual Inquiry* and Design for adults, Cooperative Inquiry adapts the techniques of these methods for use with children. Cooperative Inquiry is a method of design partnering created to *design technology with and for children*. In the Cooperative Inquiry method, adults and children use a broad range of techniques to work together throughout the entire design process to create new technology. Although Cooperative Inquiry has been primarily implemented with children aged 7 to 11, there have been forays into using it with children whose ages span from 5 to 18.

The techniques of Cooperative Inquiry include *bags of stuff*, *sticky noting*, *journals*, *mixing ideas*, and *layered elaboration*. Bags of stuff are bags of art supplies or low-tech prototyping supplies (i.e., felt, glue, feathers, and Styrofoam) that children and adults use together in order to “sketch” ideas for designing new or enhancing current technologies. Sticky notes are used to offer specific design suggestions for an existing technology or prototype. Sticky notes are written one per note by design partners, and then are grouped and discussed using an informal frequency method. Journals are used as a place where design partners can individually sketch ideas for new technology, reflect on a session, or draw or write new ideas. Mixing ideas involves each design partner beginning with an individual idea and then a step-wise progression of combining the ideas. Layered elaboration allows small design groups to expand on each other’s ideas by layering clear acetate sheets over initial concepts to add to designs without affecting the original. These Cooperative Inquiry techniques have all been designed to support *idea elaboration* between the intergenerational members of the design team. Using these techniques, many team members contribute to and improve upon ideas as they become new technologies. A full description of the Cooperative Inquiry method and its techniques can be found in the publications of Druin et al. [29, 31, 37, 51], as well as later in Section 5.

Along with the specific techniques of Cooperative Inquiry, there are underlying tenets of the process which support the philosophy of design partnering. While the goal is to give children a voice in design process, an important feature of Cooperative Inquiry is its intergenerational nature in equally valuing the voice of both children and adults in the design process. In Cooperative Inquiry, children and adults work as partners. The adults do not teach or guide children in the traditional sense; rather, adults and children are peers in the process. Adults are experts in areas such as computer science and visual design, while children are experts in knowing what it is to be a child today. This allows children and adults to be equals in the context of the design team. It is therefore necessary to address the different power structures that typically exist between children and adults. This parity is accomplished through techniques such as having both adults and children dress casually, ensuring that everyone sits at the same level for activities, and using informal language [31, 82]. Adults and children are on a first-name basis, and enjoy participating in informal activities to get to know one another, talking to each other as equals, and sharing a snack and discussion at the beginning of each design session. Since the goal is to give children a voice in the design process, adults listen to children, validate their input, and work with them to elaborate on their ideas. Children are encouraged to change and mold ideas suggested by the adults as well. The rationale behind enabling children to become equals with adults is that it supports a better flow of ideas and better idea elaboration between adults and children, which ultimately may lead to better technology.

Cooperative Inquiry offers a chance for in-depth involvement of children over the long-term of a technology design process. As we mentioned earlier, this leads to empowered children, as well as a wide range of creative and innovative ideas for pushing forward the frontier of technology. However, maintaining a Cooperative Inquiry design team requires an investment of resources in terms of time, money, space, and people. Thus, a design team considering Cooperative Inquiry as a technology design method must first ensure that they are ready to make the commitment necessary for the team to succeed.

4.6 Children as Software Designers

Another way children can participate in the design of new technology — apart from the involvement of informants and design partners — is that children can be software designers without significant interaction with adults during the design process. While the focus of this monograph is on design processes that involve both adults and children, we include Section 3.3.2.2 as well to give a fuller perspective of the range of involvement that children can have in the design of their technologies.

Children as Software Designers has been advocated by Kafai and has been employed mainly with children aged 8 to 12 [65, 66, 67]. Using this design method, children become software designers and developers; adults are not involved in the process other than to teach children the technological skills they need to carry out the process [66]. This differs from the role of design partner because here the creators are the children with little to no involvement of the adults. With Kafai's children as software designers, the children are either working alone or with peers only, not with adults. Additionally, the software that these child software designers create are usually not intended to become products for a larger audience, whereas the technologies designed by children in the roles of user, tester, informant, design partner, or bonded design team member are intended for wider distribution.

An essential component of this kind of design is that children are programmers of software for their peers [65, 67] which is distinct from design partnering where adults and children work together. Children as software designers work individually or possibly with a small number of peers, but they are not necessarily involved in a team process where they share the stakes with an interdisciplinary, intergenerational team of adults as child design partners do. They are not sharing ideas with, and evaluating the work of, adults. Thus, the social processes involved for children as software designers are different from those for children as design partners.

5

Techniques for Designing with Children

While the methods above all had the goal of designing technology for children, techniques are generally more focused. Techniques are design activities that are used at varying points in a design process to address certain sub-design goals. In general, methods — such as those mentioned above — involve design activities or techniques during multiple design stages in order to accomplish varying processes and goals. Within the various methods described above, several techniques are used. We define a technique as one activity that a design team participates in while creating a technology. As mentioned earlier, Walsh et al. [122, p. 2893] define a technique as “a creative endeavor that is meant to communicate design ideas and system requirements to a larger group”. Thus, a technique is one activity intended to do this. The work by Walsh et al. [122] is also valuable in that it sets out a framework for describing techniques along a variety of dimensions, including maturity of design and portability of technique. We refer readers to that work as a good complement to the current monograph.

In this section we describe several techniques that are used that involve both children and adults in the design process, primarily as informants or design partners. In presenting each of the techniques we

Table 5.1. Design techniques and their relation to the general design goals.

Technique	Design Goal				
	Define problem	Research problem	Create solutions	Evaluate solutions	Reflect on outcomes
Fictional inquiry	X	X			
Mixing ideas			X		
Storyboarding/comicboarding			X		
Layered elaboration			X		
DisCo			X	X	
Sticky notes				X	X
Fun toolkit, surveys, this or that				X	X
Focus groups	X	X	X	X	X
Large group discussion (using whiteboards)	X	X	X	X	X
Documentation and design tools					
Journals	X	X	X	X	X
Online journals	X	X	X	X	X
Digital cameras	X	X	X	X	X
Video	X	X	X	X	X

also relate it to its method of origin if it has one, and state the ages of the children with whom that technique was originally used. The method and age are for reference only as many of the techniques can be adapted for other purposes, for use with other methods, and for children with different ages. We do not directly associate techniques to one method as they can be used within diverse methods. Instead we indicate the design goal(s) that correlates with each technique. Below we give specifics about several design techniques that involve children as informants or design partners. Besides describing how to perform the technique, we also situate the technique in terms of the aforementioned design process sub-goals (see Section 2). Table 5.1 summarizes the techniques and the design goals addressed by each technique.

5.1 Fictional Inquiry (Requirements Gathering, Brainstorming)

One brainstorming technique that can be quite motivational to children is Fictional Inquiry. In Fictional Inquiry, children are asked to

participate in a make-believe scenario through which a narrative is set up to gather many requirements from children. Two well-known and proven Fictional Inquiry techniques for brainstorming are Mission to Mars and KidReporter. As with other brainstorming techniques, these are best used early in the design process and child design partners should not be limited in their thinking. The primary design goal is to research the problem and gather requirements that may help later in creating and evaluating solutions that are created further on in the design process.

In Mission to Mars [26], adult designers establish a scenario where child design partners are contacted by “Martians”. This can be done using the video camera, monitor, and speakers. The “Martian” adult is in a separate room broadcasting a message to the rest of the team. During the first session, a design problem should be established. This works well as children often respond to the idea that an alien, someone who has not been to our planet, might not understand our world. Children may sometimes be hesitant to explain their thinking to adults, whom they assume should already know many of the things that they know. However, explaining ideas to a Martian frames the activity in a new way which may encourage more complete descriptions from children. After this initial brainstorming and as the sessions continue, child design partners continue to design to the problem and create solutions for the Martian. In a final session, small groups of children can present their ideas to the Martian. This technique was originally conducted with children aged 10 to 11.

Another Fictional Inquiry technique that can be used in the brainstorming phase of design is KidReporter which was originally used with children aged 9 to 10. KidReporter [10] can be used not only to generate user requirements for a specific product, but also as a way to gather and determine interesting content for a product. In order to use KidReporter, generally adult design partners determine the type of product they wish to design. Once they have the product in mind, the designers create a scenario in which child team members become reporters, photographers, and article writers. This is the “fictional” part of this Fictional Inquiry, where students are asked to participate in a narrative that encourages them to be free with their ideas. If adult

design partners were merely to ask children for ideas on a topic, the children might be reticent to give the ideas. However, by asking the children to create a “newspaper” from which adult designers can infer design and/or content requirements, the likelihood grows that children will offer more ideas.

In Fictional Inquiry, adult designers take the data gathered from the output, such as the videotapes of children explaining processes to a Martian, or the newspaper that children produce in KidReporter, and sift through and identify the requirements and big ideas that were generated. Adult designers, possibly with some help from child co-designers, could then begin to determine which ideas to pursue as the design process continues. Costs of these techniques include the video equipment which may be needed, as well as any art supplies.

Fictional Inquiry can be used in many potential design scenarios. For example, Fictional Inquiry techniques of brainstorming and designing have been used successfully in designing technology for children, including an interactive floor intended for use involving children with cochlear implants [62].

5.2 Bags of Stuff (Brainstorming)

Apart from Fictional Inquiry, there are other ways to brainstorm within design processes with children. Most design processes in which children are design partners include a technique or techniques for brainstorming which are intended to elicit as many ideas as possible from the team. Cooperative Inquiry [28], primarily used with children aged 7 to 11, includes a brainstorming technique formally named *low-tech-prototyping* but is more often referred to by adult and child design partners alike as *Bags of Stuff*. The primary design goal for Bags of Stuff is one of creating multiple solutions.

When using the Bags of Stuff technique, the large group is generally first presented with an early stage problem to be solved. Then, designers are split into smaller groups. Generally these groups are a mix of adults and children. A high ratio of adults to children is ideal; groups of 3 to 5 team members work well, with 2 or 3 children and 2 or 3 adults per group.

Each group then receives a bag of low-tech art supplies. Supplies could include, but are not limited to, items such as crayons, construction paper, scissors, glue, tape, glitter, yarn, toothpicks, cotton balls, markers, tubes, Styrofoam shapes, straws, clay, etc. The cost of the art supplies is on consideration in deciding to use this technique. It is ideal to include three-dimensional materials, especially if the technology to be developed is physical in nature. Once the groups have their bags, they will function differently: some groups prefer to talk about the problem first, while others will prefer to dump out the bag and dig in and immediately begin to build from the art supplies. Using the Bags of Stuff, each group brainstorms a solution to the larger problem and builds a low tech prototype of that solution. It is important for adults to attend to the dialogue that occurs during the bags of stuff brainstorming process as the resulting prototype may not represent all of the ideas expressed in the verbal discussion while creating the low-tech prototype. This adult role then not only includes building, and facilitating a collaborative and elaborative experience, but should also include writing down notes of conversations that occur during the low-tech prototyping process. While the artifact itself is important, the building of the model and the discussion and elaboration that occurs around the prototype generally provides rich content and directions for the research.

While the groups are working on their prototypes, one adult team member should float from group to group. This team member will get an overall feel of the direction that the groups are headed. Finally, once all prototypes are completed, groups should come back together and present their ideas to each other. The floating adult should listen as each group presents and pull out the big ideas that emerge. Typically the big ideas are then written for everyone to see on a surface such as a white board. The final step is for the adult who wrote the big ideas to review them aloud with the group, noting patterns, frequencies, and surprises, and being sure to check with the group that no important ideas were missed. After the session, adult team members should meet to determine which ideas will be pursued further in the technology design process.

Within Cooperative Inquiry, Bags of Stuff has proven useful as a brainstorming design technique. It has been used in the creation of many innovative technologies, including Tangible Flags, which used tablet computers to enhance learning on field trips [23], as well as Mobile Stories which uses mobile devices to support children in collaborative reading, creating, and sharing of stories [34]. Not only has it helped to generate many ideas for new technology, it has also proven useful as an icebreaking technique when a new partnership or team is established. The low-tech nature of the art supplies tends to level the playing field between adults and children, allowing for a more relaxed and honest flow of ideas, and for a good way for designers to get to know each other. Low-tech art supplies also tend to be inexpensive, making low-tech prototyping a financially feasible technique for many design teams.

5.2.1 Variations of Bags of Stuff

Low-tech prototyping or “Bags of Stuff” can be varied depending on individual project circumstances. Some variations to Bags of Stuff include “2D Bags of Stuff” and “Mobile Bags of Stuff”. In 2D Bags of Stuff, supplies are limited to two-dimensional arts and crafts items such as colored paper, markers, and foam board. This is particularly suited for prototyping purely two-dimensional interfaces such as desktop or tablet computers, or software such as online computer games or a website. 2D Bags of Stuff also has the benefit of being less bulky than traditional Bags of Stuff, which intentionally include 3D materials such as styrofoam balls and spools of thread. The flatter nature makes 2D Bags of Stuff more appealing for “Mobile Bags of Stuff”.

Mobile Bags of Stuff have been used in the design of mobile device systems and applications, such as designing for mobile phones or other hand-held devices. In Mobile Bags of Stuff, designers have all of their supplies in a see-through plastic bag with handles. This allows for the designers to engage in the types of mobility that will be inherent in the end product. Flat, small bags with handles facilitate prototyping on the go. Teams are encouraged to move outside of the traditional design space, such as the lab, in order to prototype in varied contexts where

mobile technologies may exist. When design teams have bags of art supplies that can be used in context, they are afforded the opportunity to design in the context that the technology will eventually be used.

5.3 Mixing Ideas (Brainstorming; Iterating)

The Mixing Ideas technique grew out of Cooperative Inquiry work with young children [52]. Younger design partners (aged 4 to 6) may need more support in order to combine their ideas during the ideation or brainstorming phase of the design process. They are relatively good at coming up with individual ideas; however, they are often reticent to combine their ideas with others'. Thus, the Mixing Ideas technique grew out of a need to combine the ideas of many individuals into one idea. The primary design goals in mixing ideas are to create and refine multiple solutions. In order to do Mixing Ideas, teams need: paper, both large and small; drawing and writing implements such as crayons and/or markers; and tape and scissors. As with low-tech prototyping, these materials are typically relatively inexpensive.

When using the Mixing Ideas technique, we have found it useful to use the analogy of baking cookies. While the ingredients of a cookie may not taste good on their own (i.e., flour or baking soda) or they may (i.e., chocolate chips), we agree that when they come together they make a delicious whole that would not be possible with any one ingredient alone, or even with the exclusion of one of these important ingredients. Another analogy that works well with young children was the idea of mixing colors. Red is just red, and blue is just blue, but if you combine them you get something different altogether that you could not have individually: purple.

Mixing Ideas works best when each activity is done during a different design session. Thus, designers considering this technique need to consider if multiple sessions are a possibility for their design team. Spreading Mixing Ideas over a number of sessions allows time both for team members' ideas to grow and for each member to become emotionally less attached to their individual ideas. In the first session, the leader presents the team with the problem to be solved. Each individual team member sketches ideas using crayons, markers, and paper. In the case

of very young children, adult team members can annotate the drawings with words. Between sessions, adult team members should review the sketches and note any that have similar ideas and are thus likely to be easily combined. Also, adults generally capture pictures of the artifacts to document the ideas as the artifacts will be dismembered in subsequent design sessions. In the next session, the team members are assigned to pairs, who then “mix ideas” together. Adult team members can facilitate this mixing. Children should be encouraged to use tape, scissors, and new paper to either cut up and glue together initial ideas or to create a new drawing of the mixed idea. Again, between this session and the next, adult team members review the sketches looking for similarities that may be more readily combined in the next session. In the next session, repeating the feel of session two, ideas are combined by pairs into small groups. Depending on the team members and the ideas, it is possible that the sessions will end here with a few design ideas, or the large group can continue to combine ideas in another session to yield completely collaborative idea(s). Then, adult design partners can analyze the final idea for thoughts on how to move forward in the design process.

This technique was created for use with younger design partners (aged 4 to 6), but it can also be beneficial when starting a new design team with older children where all participants are new to the team. In such a case, the children and adults are just learning to trust one another with their ideas and are learning how to work collaboratively. This technique can ease the initial apprehension of working with others. The act of Mixing Ideas is a structured manner as described in this technique allows children to see how their individual ideas combine with other’s ideas to become a stronger end product. When children can trace the evolution of the large idea and their voice in it, they feel a sense of individual ownership in the collaboratively created product.

5.4 Storyboarding/Comicboarding (Brainstorming)

Storyboards are graphic visualizations created to illustrate a sequence or progression [55]. Moraveji et al. [83] suggested variations of traditional storyboarding to make it more appropriate for use with children.

One technique is called *Comicboarding*. Comicboarding is a variation of storyboarding intended for children that has been used to brainstorm with children aged 6 to 13 who need support in brainstorming. These can be used early in the design process to depict user interactions and to capture user scenarios, cases, and tasks [117]. In Comicboarding, a child and an adult work together to fill in a partially completed comic using paper and pencils. Children are given the option of narrating their ideas to have the adult illustrate for them. Researchers found that by using a familiar construct, the comic, along with the scaffold of having a skilled artist offers to draw ideas dictated by the children, the children gave more ideas than they did with a non-scaffolded traditional storyboard technique. A further enhancement of traditional Comicboarding was created in Magic Comicboarding. Using Magic Comicboarding, a child and an adult sit in two different rooms. The technology utilized is PowerPoint and two connected notebook computers. As the child narrates ideas, the adult (from the other room) draws the ideas, which appear “magically” on the child’s computer. Both Comicboarding and Magic Comicboarding are ways to brainstorm ideas with child design partners, and to support this brainstorming with children who need additional scaffolds to brainstorm freely. Although Comicboarding was not designed as part of a particular method, one can imagine it being used in the context of other methods, such as Bonded Design or Cooperative Inquiry.

5.5 Layered Elaboration (Brainstorming; Iterating)

A brainstorming technique developed for use in the Cooperative Inquiry method with children aged 7 to 11 is called Layered Elaboration [121]. Layered Elaboration is best used for brainstorming when designing screen-based media, when combining the ideas of distinct groups, and when expense, time, and space are limited. The primary design goal is to create multiple solutions. This technique evolved when our team realized that oftentimes, children and other designers do not like to “ruin” the work of other designers. Even if the work in question is a low-tech, initial, brainstormed prototype, designers, especially child design partners, can be sensitive to changing the work of others in a way

that they perceive as permanent or destructive. This can hinder elaboration. By its very nature, the elaboration process involves changing, extending, adding to, and subtracting from the ideas of others. Layered Elaboration allows designers the ability to elaborate on others' ideas without "ruining" the initial idea.

The financial cost of employing Layered Elaboration is fairly small. In order to use this technique, teams need plain white paper, clipboards, binder clips, and permanent markers. The one unusual supply required for this technique is write-on clear transparency film. These clear acetate sheets can generally be found in office supply stores and are the same as the transparency film that used to be common place in schools for use with overhead projectors.

In order to employ Layered Elaboration, the design team as a whole should be presented with the problem to be solved. Then, the large team is divided into smaller groups. Each group should have a piece of blank paper on a clipboard along with markers. On the blank paper, have one team member puts a "+" in each corner, as well as any identifying marking such as the title of the problem, the identification of the group, and the number of the layer.

From here, the small groups create their initial solution to the problem on the paper, after which all groups come back together for a "stand-up meeting" where each group briefly presents their ideas to the other groups. The purpose of this meeting is for everyone in the large group to understand the ideas of each small group. This meeting is identified as a stand-up meeting in order to encourage members to give a brief overview of their design so that the next iteration can occur and too much time is not spent on each explanation.

Groups then pass the initial ideas to another group. Each group puts a clear overhead transparency on top of each initial idea, along with the registration points and the new group's identity. Then, the new groups elaborate on the initial idea by adding to, editing, and changing the initial storyboard. However, all changes are made on the transparent overlay, and deletions are indicated by crossing out ideas instead of erasing them, thus leaving all iterations intact.

From this point, the whole group should continue with stand-up meetings and new transparencies iteratively until each group has had

a chance to elaborate on each idea. Once all groups have had a chance to design on each problem, a final debrief is held. During this meeting, each group presents the final, elaborated idea. One adult can record the ideas of all groups in a central location. This adult leader can then note and discuss with the whole team the “Big Ideas” so that all members of the team have an idea of the overall themes that have emerged from the session. As with many other brainstorming techniques, the next step is for members of the design team to sit down with all of the information that emerges from a Layered Elaboration session and decide which of the many ideas to pursue further.

One technology created in part by using Layered Elaboration is Energy House, an interactive game designed to teach children about energy conservation [121]. The design team began the process for this technology by participating in a Layered Elaboration session with the prompt of thinking about how to conserve energy in their home, at school, and at a National Park. What eventually emerged was a game in which children had to work together to physically power (by jumping on a mat) the electrical items in a home. Of course many other design techniques occurred throughout the design process of Energy House; however, Layered Elaboration was used for the initial brainstorming.

5.6 DisCo (Brainstorming; Iterating)

DisCo (short for “Distributed Collaboration”) is a tool designed to support collaborative technology design with geographically non-located, asynchronous, intergenerational groups [119, 120]. It was originally designed as an extension to Cooperative Inquiry design with children aged 7 to 11. Using an easy-to-understand interface that runs on computers with access to the Internet, DisCo supports asynchronous co-design in which child and adult design partners may be geographically non-co-located. DisCo allows child and adult designers to iterate, annotate, critique, and communicate about new technology designs via a web-based interface. The eventual goal of DisCo, and the motivation behind its creation, is to connect children across the globe, including those in the developing world, and allow these children to design technology together by accomplishing many of the goals in the design

process, but most particularly the goals of creating and evaluating multiple solutions. The ability of DisCo to support asynchronous co-design is intended to empower children in time zones that are far apart, such as India and England, or Australia and Canada, to work together to design technology.

DisCo began as an online implementation of Layered Elaboration. Non co-located designers can add layers to previous prototypes and to make additions or edits to the prototype, as well as make annotations about their changes, at any time. Designers can turn the layers on and off so they can or cannot be seen. Thus designers can add to or make dramatic changes to prototypes in a collaborative manner while co-designers are in different places and working at different times. DisCo has grown throughout the design cycle, and currently includes additional affordances such as space for informal messaging between design partners as well as supporting other techniques such as ways to critique iterations of design online.

There are some financial considerations in using DisCo, including that each site would need to have access to computers to run the software. Also, each team needs to have the human resources to run the sessions in different locations; however, the trade-off gained in allowing children to co-design with children across the world is beneficial in today's shrinking world.

Choosing a Brainstorming Technique

Numerous brainstorming techniques exist in co-design with children. However, there are criteria which make certain techniques more useful for certain types of early design process work, depending on the design problem that is being addressed in a given session. Sluis et al. [105, 106] began research in the area of determining which early design processes are best for specific types of early design questions. They found that children came up with many *ideas* for new technology as a result of a low-tech prototyping activity; however, the children expressed more *criteria* for a technology after a verbal and written brainstorming activity. Studies such as these indicate the need to carefully choose the technique that designers employ with regard to the goals of a design session.

5.7 Sticky Notes (Evaluating)

The sticky notes critiquing technique is a part of Cooperative Inquiry where children aged 7 to 11 and adults work together and critique an existing technology or prototype. The goal of the technique is to evaluate prototypes and provide feedback and direction for future improvements of a given technology. The technique requires a few supplies, namely: sticky notes (e.g., Post-it notes), pens/pencils, and a large vertical writing surface and implements (e.g., dry erase board and markers). Thus, the financial overhead for sticky notes is low.

The process of the sticky note technique is to first distribute sticky notes and pens/pencils to each member of the team including children and adults. Team members then interact with the technology that is to be critiqued. This could be a technology that has already been developed and deployed, or a prototype at any point of development. Sticky note critiquing can be done individually, but often more ideas will be shared if design partners work in pairs or small groups. Each team member writes down their ideas or observations of the technology on the sticky notes. Each idea or observation should be written on a different sticky note, so there is one idea per sticky note. Adult partners not only critique the technology by making their own sticky notes, but they may also act as facilitators to help children write or express their ideas. If the child design partners express something verbally but do not write it down an adult facilitator should remind the child to share their observation on a sticky note. If a child has difficulty in writing, an adult can act as scribe or the child can draw the observation. Before starting, the team is asked to focus their ideas on a set of categories. These categories often include things you *like* about the technology, things you *dislike* about the technology, *surprises* about the technology and/or *design ideas* for the technology. Not all categories are used for each sticky note session. While there is some flexibility in the categories, generally these categories are decided on *a priori* depending on the focus of the session. The hands-on interaction and writing of sticky notes portion of sticky note evaluation sessions generally last for 20–40 minutes. This allows team members to interact deeply with the technology and document all of their likes, dislikes, surprises, or design ideas.

As team members write down their ideas — one per sticky note — an adult team member collects them. As the sticky notes are collected, a member (or members) of the team arranges the sticky notes on a large vertical surface grouping notes with similar items (e.g., topics such as colors, buttons, audio, etc.). These categories are not decided upon beforehand. Grouping the sticky notes in this fashion allows for patterns to emerge from the teams' comments which can then be used to indicate what areas should be emphasized in future work. As groupings emerge, the leader circles and labels the group of sticky notes. When the team is done writing their observations, they come together and discuss and review the patterns that emerged. This allows team members to clarify their ideas, and helps solidify the categories that emerged throughout the session. It is also a time to discuss areas of focus for future design sessions, which typically are the largest or most surprising groupings of sticky notes.

At times it can be useful to color-code sticky notes by demographics, such as giving all females one color and males another, or younger team members one color and older team members another, if demographic differences are informative to the design. Color-coding the demographics allows the team to easily observe visually if different groups are keying into different design issues.

While the above described technique is how sticky notes are employed in the Cooperative Inquiry method with children aged 7 to 11, sticky notes have been used by designers in many ways and sticky note techniques can be adapted for younger children (aged 4 to 6) as well as older children including teenagers [37]. Many technologies have been created in part using iterative sticky note critiquing. For example, the International Children's Digital Library (ICDL, www.childrenslibrary.org), a large, multilingual, online library of children's books, was the subject of many sticky note sessions throughout its iterative design process.

5.8 Fun Toolkit, Surveys, This or That (Iterating; Evaluating)

As mentioned in Section 2, evaluation includes both formative evaluation, which occurs during the iterative design process, and summative evaluation which occurs at the end of a design process. Both

types of evaluation are good practice in technology design. Formative evaluations help to guide future iterations of design. Summative evaluations give designers feedback on existing technology.

There is a large body of literature regarding evaluation for children's technologies. Read et al. [96] created a Fun Toolkit for measuring the fun that children have when using technology. These tools measure durability, engagement, and expectations. The tools include a Smiley-o-Meter, which is a Likert-scale adapted for children; a Fun Sorter, in which children are asked to rank the relative fun of a variety of activities; and the Again–Again table, in which children are asked to tell if they would do an activity again. Read and Markopoulos [99] also suggest surveys, questionnaires, and diaries as methods for evaluation of projects with children. Recently, Sim and Horton [104] have measured the comparative effectiveness of differing methods of evaluation for children's technology. In this work, they employed the Fun Toolkit mentioned earlier in this section as well as a newer method for evaluation called This or That, which is derived from the idea that asking children to do a pairwise comparison imposes only a minimal cognitive load on children. Their work showed that although each method had benefits, there was a 70% reliability between the two methods, and the authors have called for future work to enhance the reliability of children's evaluative tools for technology.

These types of evaluation tools can be helpful during an iterative design process. As with focus groups, it is best if these types of evaluations, even when done iteratively, are carried out with children separate from those who are design partners. Again, just as we do not expect adult designers to evaluate their own technology in an unbiased fashion, we cannot expect children to do so, either. Gathering evaluative information from children other than design partners during a technology design process can lead to further and differing ideas as the team pushes forward the design.

5.9 Focus Groups (Requirements Gathering; Brainstorming; Iterating; Evaluating)

When conducting focus groups several factors need to be addressed. We present a summary of what others have previously published in this area

following the same general outline of [44]. Some considerations include group composition, geographical location and scheduling, creating the right environment, moderator, introducing the group, conducting and recording the discussion, and rewards and recognition. We discuss each of these considerations briefly as they illustrate how this technique can be conducted in practice.

Group composition: all focus groups generally have some form of homogeneity whether it is in age or purpose. In terms of ideal group size, the literature provides varying advice, although marketing research group sizes tend to be larger than social science or design groups [84]. The ideal group size for social science or design groups for children aged 7 to 10 is four to six participants to maximize lively discussion and maintain manageability of all activities [69, 84]. Because children of different ages have varying styles, abilities, sensitivities, comprehension levels, and abstraction capabilities, it is suggested the range of age difference among children should be only 1 or 2 years [69]. When in a focus group scenario children may say little or nothing if they do not know each other prior to the focus group experience [79]. In order to counter this, researchers have used friendship groups or asked children to bring along their friends [48, 58].

Geographic location and scheduling: new environments and strange adults can provoke anxiety, especially for young children [69]. At the same time, a familiar location can evoke familiar responses such as a school may lead children to feel like they are in the traditional power structure of teacher–student where the adults have the answers and are looking for a specific response from the children [44]. Therefore, one should be careful when selecting an appropriate location — one that is comfortable, but not too familiar, for the children. Scheduling can be problematic for families with children so travel is often reimbursed and/or a reward is offered. Because of this difficulty, one-time experiences such as focus groups can be appealing. Participants generally enjoy one-time experiences not only because of the smaller commitment of time, but also because they are generally organized to optimize enjoyment while still facilitating feedback [57].

Creating the right environment: when preparing focus groups, great attention must be given to creating an atmosphere of comfort and trust

so that true feelings and opinions can be expressed [71]. Part of this is room layout choice (a circular setting is often preferred), lighting, and even having a comfortable temperature level in the room. When working with children, it is important to address the traditional power structures that exist between adults and children — where children generally feel adults have the answers and their role is to figure out the “right” answer the adults already know. This is not the desired relationship in a focus group, so often during focus groups facilitators have children call adults by first names, sit on the floor with children, permit limited “fiddling” with toys, and sessions often include “ice breaker” activities in which adults and children both participate [44, 84].

Moderator: the moderator plays a key role in facilitating discussion amongst the group. The moderator role is crucial and requires a positive personality and skills to engage individuals and groups [69]. While experts may make this process look easy, the complexities and difficulties of moderating a focus group requires preparation, practice, confidence, familiarity with the questions, and an ability to sense the specific dynamics of each unique group [44].

Introducing the group: it is important to clearly describe to child participants what will be happening during the focus group [44]. This includes describing the roles of the adults so the children understand why there may be other adults walking around taking notes or doing other background tasks while they are talking or working. Children should understand why they have been asked to participate and what is expected of them. All recording methods need to be divulged to the children up front, not only to appease ethical requirements but to put the children at ease and to build the relationship of trust.

Conducting and recording the discussion: focus group sessions must be well-planned including initial and subsequent questions and activities [44]. Open-ended questions will yield more results than closed, yes-no questions. It is also beneficial to give all children an opportunity to respond to each question [69]. Verbal and non-verbal responses can be recorded by an assistant moderator who can take notes and/or sessions can be audio or video recorded and subsequently transcribed. Various exercises and activities can be used during the focus group sessions including a variety of techniques from participatory research

methods such as drawing, role-playing, puzzles, visual prompts, and brainstorming [44, 69, 115]. Using such activities can lengthen the concentration period of the children from a traditional 45-minute session to a 90-minute session [44].

Rewards and recognition: some people believe that children should be compensated for their participation in a focus group [84]. Common compensation practices include reimbursing travel expenses for the participant and their family members, a small gift (such as a gift card), and verbal/written appreciation for their participation. If outcomes from session are used it is courteous to notify attendees of the results whether they be product modifications or research publications.

Focus groups can be a resource-light mechanism to get child feedback during an iterative design process although the feedback may be limited by the time allowed to give it as well as the children not being vested in the co-design process.

5.10 Large Group Discussions Using Whiteboard (Brainstorming; Summarizing Ideas)

At the end of many of the techniques mentioned above — particularly those in the Cooperative Inquiry method — the large group comes together to discuss individual or small group’s ideas. In many cases, this is the *big ideas* part of the session. While small groups present ideas, an adult design team member writes the ideas on a large whiteboard, grouping similar ideas together. Through the process, designers can begin to see where ideas overlap, and which ideas get the most “ah-hah” innovation response. Both of these are helpful in guiding future design. Often it is these frequent or surprisingly different ideas that can push forward and lead to innovative design.

Another way in which large white boards can be used is for quick frequency analysis. Sticky notes can be grouped showing quickly the areas of concern for, and positive design features of, a technology. A large vertical space for gathering the ideas of an entire team is extremely beneficial.

5.11 Documentation and Design Tools (Requirements Gathering; Iterating; Capturing the Process)

Tools that have primarily been used by researchers in observation, such as journals, cameras, and video recordings, also have use in the design process. There are many uses for documentation tools in the design process. They can be used by child design partners to ascertain user needs and requirements, or for data collection. They can also be used to encourage children to participate in the design process. They can be helpful to collect documentation of the design process. We will examine a few documentation tools and their specific affordances in turn. The tools we present are journals, online journals, digital cameras, and video.

5.11.1 Journals

The lowest-tech documentation and design tool is a simple journal. Each researcher, child and adult alike, can have a paper journal. In Cooperative Inquiry design, we have found that the best journals are small for easy transportability, have hard covers for protection and durability, and are filled with unlined paper. Blank, unlined paper allows the children and adults to either write or draw their design ideas.

Journals can be used in a number of ways. Some young design partners like to take notes during design team sessions that they can refer to when presenting ideas. Throughout or at the end of sessions, design partners can be asked to draw or write design ideas, or critiques of technology, in their journals. These can be referred to later in the design process. Adult design partners can review the journals for ideas for new and interesting directions that a specific technology might take, or for overarching ideas for general directions for exploring new technologies.

We find that children are more likely to share their ideas if they are allowed to do so in the way that they choose. Since Cooperative Inquiry is not intended to teach children to write, they are offered the option to draw or to have an adult write down their ideas for them. This way, the design ideas are not stopped by the communication format they are required to take.

5.11.2 Online Journals

Online journals can be used as a motivating way to encourage child design partners who are reluctant to draw in a traditional paper and pencil journal to instead record their ideas in a technologically enhanced fashion. The simple introduction of technology to the equation is motivating for some children. We have found this to be especially true of slightly older children, aged 10 to 13 [113]. Using an online journal format, child design partners can take the same kinds of notes or sketch ideas in a similar fashion to paper journals, but can also take advantage of tools unique to a computer environment in doing so. Similar to paper journals, the ideas in online journals can help to guide technology design.

5.11.3 Digital Cameras

Digital cameras can be used at various stages including requirements gathering. They can be used to obtain cultural probes into children's lives, that is, to provide information about their lives that might otherwise be unavailable to the design team [92]. This is valuable for designers who want to design for a child's world. Child design partners can be given digital cameras to take out into the world and to capture the real world of either their daily life or that of their peers. This gives the adult designers access not only to what is happening outside of design team in the lives of children, but also to what the children believe is important in their lives. This type of digital requirements gathering can help design teams to identify areas of need for technology design. These digital photos can also be used as a type of requirements gathering in which the information gained in analyzing the pictures is used to inform the design of technology. Digital cameras are also very helpful for documenting the design process and intermediate design activities and artifacts including prototypes at various stages of development.

5.11.4 Video

A final documentation tool that can be used in designing with children is video cameras [61, 72]. Video cameras can be used to encourage

children to become more involved in design processes. Sometimes, children who are reticent to participate in the design process can be convinced to do so when given a video camera. At Cooperative Inquiry design sessions, video cameras are often used to document sessions so that designers can later reference the tapes. Thus, the children involved are generally comfortable with the presence of video cameras in the sessions and are usually not overly shy or silly for the cameras. Giving a shy child the chance to be the person documenting a design activity with a video camera can be an icebreaker into more deep participation. Video cameras can also be used to elicit information from children. Allowing other children to instigate investigations via interviews can also be beneficial. A child with a video camera can participate in the design process in numerous ways.

5.12 Summarizing the Techniques

In this section, we have presented several techniques that are used to design technologies with and for children during various stages of the design process. While we have presented several techniques, this is by no means an exhaustive review of the techniques that are used. Other techniques are available, and variants of the techniques presented could also yield valuable prototypes and designs. We continue to explore more techniques in our own research, and hope to continue to learn from our fellow colleagues who have identified and adapted new ways of giving children a voice in the design of their technologies.

6

Revisiting the Underlying Dimensions of Child Involvement

Druin [29] originally described three dimensions which underlie the roles of user, tester, informant, and design partner (see Figures 3.1 and 3.2). These dimensions were the relationship to developers, relationship to technology, and goals for inquiry. These dimensions are no longer sufficient to characterize the evolving methods and techniques, nor are they sufficient to describe the world that we now live in and the involvement and relationship that children have with technology. Advances in and the broad proliferation of communication technologies have helped fuel the emergence of a global community. No longer do people need to work side-by-side in a collocated setting, nor is this opportunity always available. Techniques such as eCodesign and DisCo are now addressing the need to accommodate design partners in different locations. Another emerging difference is that the amount of content that is available to children has dramatically changed. It used to be the case that children would interact with technology through a discrete program that had a finite body of content built into it — like a CD-ROM. However, now the scale of content has changed. Now children can have access to, what is in essence, infinite content via the Internet. This changes the way that technologies need to be designed,

and an understanding of the scope or scale of content accessible through the designed technology is a factor in the method and techniques that should be used to design that technology. Lastly, technologies have evolved to the point where the ubiquitous computing vision shared by Mark Weiser is becoming more and more a reality [123]. There is a broad spectrum of technologies ranging from tangible interfaces, to mobile devices, to tablets, to desktop computers. How these technologies and new ones are employed forges a relationship between children — the users of the technology — and their physical world. This relationship is also a key consideration when designing technologies for children. Figure 6.1 illustrates the original dimensions along with these three additional dimensions. These dimensions are important for designers to consider as they select the methods and techniques they employ as they involve children in the design of technologies for children. Regardless of their cognizance of these dimensions, designers who choose to use a particular method or technique are implicitly making a decision that affects the children who use the technology they develop. These effects can be characterized by these dimensions.

Looking at each of the new dimensions, we can imagine how they might impact design method and technique choices for design teams. For partner location, nearly any method or technique can be used when

Relationship to Developers	Indirect	Feedback	Dialogue	Elaboration
Relationship to Technology	Ideas	Prototypes		Product
Goals for Inquiry	Developing theory	Questioning impact of technology		Better usability/design
Partner Location	Collocated			Distributed
Scale of Content	Closed			Infinite
Relationship to Physical	Dependent	Not deep		Disconnected

Fig. 6.1 Revised underlying dimensions of children’s involvement in the technology design process (revised version of Figure 3.2).

children are collocated; however, if they are distributed, a technique such as DisCo would need to be used. Designers can also be creative and use a Fictional Inquiry technique such as Mission to Mars with a distributed group — so that one group is explaining design requirements to another via a video feed.

Scale of content also requires specific choices in design techniques. For example, if a design team is designing for open content, such as search engines for children, more open-ended brainstorming methods such as Bags of Stuff may be appropriate. If the content is more constrained, such as a website about a certain topic, brainstorming that can be more focused, such as Layered Elaboration, may be more appropriate.

Finally, the relationship to the physical can and should guide the choice of design technique and method. If design teams are focusing on a technology for use outside, a technique such as Mobile Bags of Stuff could be employed for designing in context. Child and adult design partners may need to be given templates of the technologies they are designing for when designing — mobile phones or laptops. Physical templates such as these can serve as reminders of the type of technology being designed. Suggestions such as these can help to guide a designer's choice of technique when designing for these situations.

7

Future Trends in Designing Technology with Children

Over the past two decades, many researchers across the globe have seen the importance of including children as important members of design teams for their technology. As we move into the future of designing technology with children, it is important that we continue to value the input of children and include them on design teams of their technology. This empowers children and can add to the diversity and creativity of ideas for future technology. We also must bear in mind that just as children of today experience technology differently than children of yesterday, so too will the children of tomorrow experience technology differently than the children of today. As children grow and evolve, so must our methods and techniques for technology design.

There are many opportunities for future research including designing for diverse populations of children such as under-represented groups, and diverse contexts that include children such as families. We believe the methods and techniques presented herein provide a context and foundation for this future research. There are also opportunities for future research in the online arena as children are spending more and more time online [70]. While we have addressed some alternatives for this including common Internet communication mediums such as

email and video conferencing and even specialized software such as DisCo, there still remain many opportunities that can be explored to give children more of a voice in the design of technologies intended for them.

It is our belief that children will continue to be more internationally aware, independent, interactive, and information active [30, 53]. Additionally, we will need to bear in mind designing for the shrinking and developing world, mobile technology, social computing, and the ubiquity of search. Children are more mobile, and they expect to be more social with their technology. They are more immersed in information thanks to online search. We must ensure that as designers and researchers of children's technology, that we keep up with the ever-evolving needs of children. In our work in [46], we make specific suggestions for evolving design-partnering methods to keep up with children today. These include new techniques for distributed co-design with teams of children who are not geographically co-located, designing in context and for the particular affordances of technology, and designing for the reality of children's daily worlds.

Children are becoming more aware of the global community and their place in it. As such, we recommend the continual evolution of techniques such as DisCo designed to support children in designing for this ever-shrinking world. Along with this comes the reality that everyone across the globe does not have the same access to the same technology. As such, we should try to make our technology for children available using as many different types of hardware and software as possible in order to reach the greatest number of children possible. We should always try to be mindful of issues with deployment, such as if children everywhere will have access to the hardware and software needed for a technology, and if there are any political or social ramifications in getting that technology to them.

Mobility is becoming a ubiquitous feature in technology. Many children across the globe have access to mobile technology such as cell phones, and as designers we should leverage the affordances of mobile technology in our design as children are inherently mobile beings. We should not simply take software designed for a computer and put it on a mobile phone; rather we should design technology which uniquely

takes advantage of the mobility of both technology and children. We need to consider how these mobile technologies allow for continual interaction with the physical environment through a phenomenon we call *Mobile/Physical Switching*. Context is key in designing for mobile technologies — they should be, as much as possible, both designed and implemented in the mobile contexts in which they will be used.

Along with being mobile, children are social. Today's technology encourages and enables social interaction through technology. Children expect their technology to be social — that they can play a game on their laptop with their friend who is not nearby, or that they can share the story they have created on their mobile phone with a grandparent. We must consider not only this virtual socialization, but also physical socialization, such as two children playing next to each other on iPods, when we design technology with children today. As we do this, we must keep in mind if the technology we are using intends to support children's co-located or disparate socialization, as well as always keeping at the forefront of our design any safety concerns such as personal information issues. In the design of social technology, as much as possible, designers should try to go into the contexts in which the technology will be used, and try to mimic the situations in which it will be used. For co-located technologies, having all designers in one room makes sense, but for non-co-located technologies, if it is possible to break up the design team into different locations, this will more truly mimic the eventual use scenario.

Finally, we need to consider the wealth of information available to children today. On the Internet, children can and are searching vast quantities of information using sites such as Google. As designers of children's technology, we should consider how children search this information, and create tools to support them uniquely in so doing. These would include support for emerging spellers and typists, as well as natural language support. As with other trends, we believe that designing and evaluating our technology in context is key when considering search technology for children.

8

Conclusion

In this monograph, we have presented the history and current state of several methods and techniques that can be employed to design technology with and for children. It is our belief that children can and should be involved in the design of their own technology, not only because this empowers children, but also because children's involvement leads to a diversity of ideas that may not exist if they are not on our design teams.

In this monograph, we presented a multitude of methods and techniques available for giving children a voice in the design of their technology. We believe the importance of giving children this voice cannot be overstated, and we hope that researchers and designers of children's technology continue to listen to and design with children even more in the future.

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