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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.

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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.

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