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The Fast-Paced Change of Children's Technological Environments

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Children are coming of age in increasingly sophisticated and pervasive technological environments. Television, DVDs, and online movies comprise part of such environments, of course. But as parents know all too well, it does not stop there. Children spend substantial amounts of time texting, instant messaging, and web browsing. Children inhabit virtual spaces, such as *SecondLife* and *Active Worlds*, which allow "residents" to explore, create, inhabit, and trade virtual property, and to interact socially with one another through avatars. Children play massively multiplayer online role-playing games (MMORPGs). This technological form of a virtual environment allows for large numbers of players to interact by controlling and developing their fictional characters in adventurous game settings. In 2006, the revenues accrued through MMORPGs exceeded $1 billion (Harding-Rolls 2007). Video games of all sorts are quickly dominating children's media entertainment, and these games are filled with dynamic, interactive, social characters (Cassell et al. 2000; Isbister 2006). Children care for and develop relationships with technological pets (Turkle 2007). Such technologies were produced at least as far back as 1996 with the introduction of the Tamagotchi, which was a small egg-shaped computational device that "needed" to be fed and regularly taken care of or it would become "unhappy" and if completely neglected would "die." Over 70 million of these devices have been sold worldwide (Takahashi 2008). In more recent years, inexpensive robot pets have also sold well, including the Teckno, i-Cybie, Pleo, and AIBO, and online virtual pets are popular.

What are the impacts of such technological environments—now and in the near future—on children's development? How do these environments affect children intellectually, socially, and morally, and in terms of their connection to space, time, landscape, and the physical and natural world? How should we design these technological environments? Which ones should we embrace or shun, or use cautiously? Where lie the most worthwhile and provocative opportunities for research and design? These are the questions of this special issue of *Children, Youth and Environments* on "Children in Technological Environments."

Through centuries past, technologies have offered enormous benefits to children. Written language, for example, can be incredibly beautiful, and compared to spoken language, the written word—from clay tablets, to pen and paper, to digital computers—has allowed for new depths and forms of communication and expression, and an unfolding of the human psyche. Yet, an important consideration when assessing the benefits of new technologies, especially those of a digital and virtual form that mediate our physical world, are which benchmarks we rely upon to establish the benefits and harms.

As a case in point, consider two studies we and our colleagues recently conducted on the psychological and physiological effects of viewing digital nature. For both studies, we mounted a production-quality HDTV camera on top of a university building. The camera captured the image of a lovely nature scene of a form that people tend to find aesthetically pleasing and restorative (i.e., including water, grass, trees, visual expanse, and sky). Through hard cabling, we then could display the real-time nature image on plasma display "windows." In our first study—the field study—we installed these plasma display windows in the windowless (inside) offices of seven faculty and staff at our university (Friedman et al. 2008). Over a 16-week period, we collected data to explore the user experience of working in an environment with this form of digital nature. Through the triangulation of data—652 pages of interview transcripts, journal entries, and responses to email inquiries—results showed that participants enjoyed the plasma-display window and benefited from it in terms of their psychological well-being, cognitive functioning, and connection to the natural world. Indeed, four weeks after the plasma display window was removed from participants' offices, all of the participants reported that they felt less connected to the local area, and that they would recommend a plasma display window to a co-worker with an inside office. Notice, however, that the benchmark here—the basis for their comparison—is a windowless office.

In our second study (Kahn et al. 2008), we assigned 90 participants (30 per group) to one of three office conditions. Each condition employed the same office, situated about 15 feet below where we had mounted the HDTV camera. In one condition, the office had a view of the nature outside through a glass window. In the second condition, we inserted into the glass window the plasma window with the real-time HDTV display of virtually the same nature view as seen through the glass window. In the third condition, we sealed off the original glass window with light-blocking material, and covered it with drapes, in effect turning the space into an inside office. In all three conditions, we then measured participants' physiological recovery from low-level stress. We found that there was more rapid heart rate recovery in the glass-window condition compared to the blank wall condition. In turn, there was no difference in the heart rate recovery between the plasma window condition and the blank wall condition. In other words, in terms of heart-rate recovery from low-level stress, the glass window was more restorative than the blank wall, while the plasma window was no more restorative than the blank wall.

Taking both studies together, our interpretation is as follows. From the field study we learn that when compared to experiencing no nature (as in an inside office), the plasma window of nature can provide important benefits. Thus, when people must work in an inside office, such technologically-mediated nature environments are probably good things. But from our experimental study we learn that when compared to actual nature, the technologically mediated nature environment was not as good. Taken together, the studies remind us that when assessing potential benefits and harms of technological environments, it matters very much which benchmarks are chosen (Kahn et al. 2007).

Children's technological environments will continue to change quickly. Investigations of the impact that traditional media has on children are valuable, but the role of interactive technologies is rapidly increasing (Comstock and Scharrer 2007). On the immediate horizon, for example, are responsive computational devices that mimic a social "other," such as intelligent navigational devices in cars that speak with a human voice while responding to our spoken demands (Nass and Brave 2005). "Smart homes" of the future will have interfaces that speak to us and respond to our actions and conversations (Harper 2003). Humanoid robots may well become tutors, nannies, and playmates for our children (Kanda et al. 2004). In the process, might children treat these social-like entities as subservient "others"—or even as slaves (Kahn et al. 2004)? These are just a few of the near future scenarios that must be considered as part of a broader program to understand the effects of technological environments on our children's development and long-term wellbeing. This is the challenge we face, and the focus of the 14 provocative and scholarly papers in this issue.

Environments Expanded

We begin this special issue with an article that expands one's conceptions of plausible technological environments. Kanda, Nishio, Ishiguro, and Hagita observe interactions between children and robots—but not just robots of the sort one might find at the local toy store. The robots these researchers have built rival our most forward-thinking visions of a science-fiction future. The article reports on two types of robots. One is a humanoid that has features similar to a human—arms, a head, eyes—but looks very much like a technological artifact. The other robot is an android, and looks in many ways indistinguishable from its human counterpart after whom it was modeled; thus, the authors call this particular type of android a geminoid. The studies conducted with these two robots provide us with a unique and powerful glimpse into a plausible but alien future in which children are taught a foreign language by humanoid robots in their classrooms and, incredibly, children interact with their parents through the mediation of geminoid robotic avatars. The two studies, taken together, show that children are likely to adapt their social behaviors and conceptions to these new technologies and accept the introduction of these technologies into their lives based, in part, on how the robotic technology is designed. The results of these studies raise further questions of how robotic technologies should be designed and what role they should play in our children's lives.

Cultural Environments

Technological environments do not exist independent of the many other cultural influences that shape children's everyday experiences. Culture guides not only the shape of technology but also the adoption and interaction behaviors of the children who come of age interacting with those technologies. We have included two articles that investigate the role of culture as a factor that can mediate the influence of a technological environment on children's development. These two articles highlight both the cross-cultural implications of technology design as well as the intracultural characteristics that can shape a child's experience of technology.

In the first article in this section, Druin, Bederson, Rose, and Weeks report on an ongoing and successful project to disseminate the International Children's Digital Library (ICDL) worldwide. With seven years of international technology development experience, Druin and her colleagues provide us with key challenges and lessons to be learned from the ICDL project. The authors provide multiple takeaway messages, one of which is the importance of acquiring site-specific knowledge within projects of international breadth. The authors recommend that any international endeavor spend significant time and resources on preparing for the potential social and technical roadblocks to success, which can include identifying and utilizing the technical and social resources available and developing awareness of social norms. Spanning sites from New Zealand to Mongolia, the authors show us evidence that culture is a significant factor in the design and adoption of successful technologies for children—and that these cultural differences can be addressed and celebrated as an integral part of the technology's success.

The second article in this section is situated within a relatively young field of inquiry called ethnocomputing, in which researchers, educators, and technology designers explore the ways that specific cultural characteristics can be integrated into technology design for the purposes of promoting learning and adoption. Eglash and Bennett report on a collection of design activities and evaluation studies of *Cornrow Curves*, a mathematics education application that uses traditional African-American hair braiding techniques to illustrate math and computing principles. Based upon the findings from their studies, the authors argue that children are more comfortable working with mathematical concepts and interactive technologies when pedagogical activities utilize culturally relevant content. Thus, akin to the lesson of the Druin et al. article, we see a specific and important illustration of the way in which children's technological environments can be improved to more accurately reflect their individual lived experiences.

Natural Environments

As *CYE* readers know well, the natural world comprises a significant part of children's environments. The relationship that children have to the natural world can be direct: an experience with nature, and its wildness and beauty. But often children's experience of nature is mediated by technology. In this section, three articles delve into how technology plays a role in shaping children's experiences with and conceptions of their natural environments.

Children's relationships to nature can be influenced by technology in a variety of ways. A common influence is through the digital representation of natural environments. Television has played a significant role in representing nature to children, and society as a whole. Virtual reality is a new form of this modality, though it goes beyond television to allow for interaction with and manipulation of the digital representations. In the first paper of this section, Harrington discusses findings from a study on virtual versus real field trips to natural settings. She found that virtual field trips could be used successfully for in-curriculum learning, but that real field trips provide greater opportunity for a breadth of learning experiences that reach beyond the curriculum.

Technology influences children's relationships to nature in other ways as well. For example, technology can augment their direct interaction with actual nature, as in the case of the paper by Chavez who reports on a study of four outdoor activities, two of which were dependent on technology. She found that the technology-dependent activities were more enjoyable to children and suggests that technology can successfully promote children's outdoor activities. Moreover, there are those experiences of nature that would be difficult if not impossible for a child to have without the advent of technology. In the final paper in this section, Harmon and Gleason provide us with a glimpse into the use of remote-operated vehicles for exploring underwater natural environments. The authors found that though there were drawbacks in controlling a remotely operated underwater vehicle, experiencing an otherwise inaccessible natural environment had important pedagogical outcomes. Taken together, the three papers in this section show how technology can be used to facilitate children's interactions with and their construction of knowledge about the natural environment.

The Developing Child

Thus far, we have focused primarily on how cultural and natural environments influence the design and adoption of technology, and how children construct knowledge as they interact with those environments. In this section we emphasize the constructive activities of developing children. We begin with an article by Freier that reviews the theoretical foundations of constructivist child psychology, and identifies six facets of the child that can provide focus to technology designers as they design systems and environments for children: embodiment, situatedness, dynamism, intentionality, sociality, and morality. The author argues that technologists can benefit from a rich understanding of child development and the particular mechanisms by which children come to understand their world. This knowledge is applicable not just to the technologies that are designed for children, but for all technologies that shape our technological environments.

As argued in the Freier article, children are not simply passive actors in a dynamic environment. They actively and reciprocally interact with the technologies around them. Building on this perspective, Henning, Brenick, Killen, O'Connor and Collins present a social-cognitive domain theoretic study on the role of video game play in the construction of adolescents' social conceptions and attitudes regarding gender roles and stereotypes. Their findings suggest that individuals both recognize and respond to negative stereotypic images while they are simultaneously shaped by exposure to those images. Whereas Henning and colleagues point to the potential harms of an unconstrained technological environment, Donovan and Katz provide a critical analysis of the security and safety constraints and restrictions that society has placed on interactions with technological environments, and how these conditions of interaction can hinder the creative expression and development of the child. Finally, we conclude this section with an article that examines the potential benefits and harms of massively multiplayer online games. Holt and Kleiber argue that individual personality and age differences may be a factor in the resulting relationship between young people and their interactions with these online games.

Learning in Technological Environments

The interactions that children have with technologies, particularly with the Internet, communication technologies, and video games, are forcing educators to redefine what they mean by learning processes and outcomes (Gee 2003). We conclude this issue with a set of papers that focus on the ways in which technological environments can support or undermine learning processes. The section begins with an article by Dieterle who investigates the manner in which an open, virtual, video-game-like technology supports a specific type of learning style—neomillenial—while potentially undermining the learning process for those children who maintain a more traditional learning style. Dieterle provides evidence that children who are accustomed to and prefer information interactions on the Internet benefit more from this new type of technology-driven learning environment.

In the next article, Rybacki provides a model technology-based educational program that relies upon a theoretical lens called Cultural Historical Activity Theory. Her work provides evidence that success can be achieved when educators and technologists consider the larger social context of knowledge production within which the technology is embedded. Considering the capabilities of the students and the affordances of the technology is also an important factor in educational success.

We also include an article on the role of technology as a scaffolding and support system for children with learning disabilities. Simpson provides a theoretically grounded argument based upon a notion of universal accessibility that simulation video game environments can be an ideal educational setting for students with learning disabilities. The emphasis that such gaming technologies place on autonomy and goal attainment naturally supports children's continued learning engagement.

Finally, Rick, Rogers, Haig and Yuill complete this special issue with a proposal for a new technological innovation, shareable interfaces, that are intended to support learning through collaborative exploration and creation. Consider a touch-sensitive, tabletop technology that allows for multiple children to work side-by-side and in collaboration as they interact with digital objects and applications. The authors report the findings of their technology evaluation, focusing on an application to support the learning of mathematical concepts. They conclude that their technology does lead to improved understanding of fraction concepts, while requiring little to no guidance by researchers or teachers. By ending with this piece, we hope to leave the reader with an example of how current, cutting edge and near-future technologies will fundamentally change children's environments.

Conclusion

Visions of the future as portrayed through media and literature (such as science fiction) are one of the powerful drivers of technological development. In the mid-1960s, for example, Gene Roddenberry, creator of the original *Star Trek* television series, saw the value of small, handheld mobile communication devices; the "flip" design of the crew's Communicators seemingly influenced the design of the common cell phones we see in use today. Our faith in the beneficence of those who play a significant role in shaping our technological future is often balanced with fears of an unknown and uncontrollable sinister force embedded within the technologies, often unbeknownst to the designers themselves. We see this tension play out in Asimov's *iRobot* series of short stories in which robots are intentionally designed to benefit humanity, but all too often the robots (and humans, ironically) fall victim to their own immense complexity.

The imaginative spaces of science fiction provide us with a stage upon which we may place the props and actors and set the stories in motion, thus allowing us to come to a greater understanding of the implications for our design decisions. For example, the android character, Data, in *Star Trek: The Next Generation*, shows us how fragile our own self-identify is when we look into the eyes of a man-machine and see our own reflection. And perhaps the woman-machine in the classic film *Metropolis* reflects our deep-seated nightmares of a future gone wrong. Our faith and our fears, our hopes and our insecurities, are uncovered through such imaginative leaps. Yet, incredibly, today's children are coming of age in yesterday's science fiction future.

Children today know no other way of being, no other way of existing in the world, than that way which brings their internal concepts into equilibration with their external environment. This process of equilibration—which leads to children's intellectual, social, and moral development—will be, and already is, strongly shaped by the technological environments children inhabit. Thus we need to design our technological environments wisely. How can we do that? The authors of this issue offer many important answers. Yet, perhaps most important of all is to remember that we are not only a technological species, but one that came of age through deep and intimate daily contact with other humans and with an embodied, physical, natural and often wild world—and that we still need that world to flourish as a species.

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