

Literature Review
Digital-Mediated Experiences and Kids' Informal
Learning

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Three questions motivate this literature review. What do we know, thus far, about the extent and ways that young people use digital media? How do digital media affect how young people learn, think, and develop? How might digital media be adapted to promote life-long learning skills? In summarizing the published literature on these questions, the paper describes what is known and what we still need to learn about how digital media are changing the experiences of childhood and young adulthood, with specific focus upon describing what is known about the emergence of new kinds of social relations, fluencies and skills, learning strategies, and modes of development.

Research addressing these questions is spread across many disciplines and professions, but often focuses upon technical devices – such as computers, handheld games, mobile phones, or games – rather than kids’ experience, learning or development. While our focus is upon research from the United States, it is important to include research from other countries that might help to clarify some of the variables that shape kids’ experiences with digital media. For example, the United States leads in the diffusion of personal computers, thus American research is often focused upon computer based applications– such as email, the Web, chat rooms and videogames. In contrast, Japan and Scandinavia lead in the diffusion of smart mobile phones, thus text messaging and mobile multimedia are the focus. Their experience may help us to extrapolate how American kids will integrate the mobile phone into their lives, for there is relatively little research on the subject in the US. What is important is to identify the emergent patterns in kids’ experiences and skills that are emerging from these technical environments – whether mobile phones or computer networks – in order to keep the focus on the kids, not on the technologies.¹

Surprisingly, there has been no systematic longitudinal study of kids’ cumulative experience of digital media from childhood to adulthood, nor of the cumulative effects of digital media upon learning and development, if they exist. Nor has the range of kids’ experience with digital media been situated within the fractures of social class, racial ethnicity and gender in any systematic way. Since the research is diffuse and often applied, the four central themes of this paper attempt to piece together the evidence that does exist in the literature. These themes are:

1. *Social relationships.* Communications networks, whether organized by the mobile phone or the Internet, are changing the scale, scope and dynamics of kids’ social worlds. Adult recognition of this change is indirect, and tends to be defined in terms of social problems, such as kids’ access to pornography or child molester’s access to kids.² But to understand kids’ emerging learning cultures, our focus will be upon

¹ The term ‘kids’ will be used as a generic for both children and teenagers because that is what they call themselves, recognizing that there are profound developmental differences that make it impossible to make generalizations about the experience of digital media by kids of different ages.

² Lenhart, Rainie & Lewis [2001] in *Pew Internet Teens Online* reports that 60% of American teens have been contacted by a stranger online, and 63% of those teens have

kids' definition of the meaning of their experiences with technology, not that of adults. What is significant is that kids are able to create and sustain new private social worlds through the use of messaging and blogging, worlds that are separate from, yet overlapping with, institutions such as family and school. Emerging kids' cultures encompass, and perhaps predict, new definitions of public and private space that sometimes transcend the boundaries that govern adult life – age and sex, institutional rules, national boundaries, and so forth.

2. *Creativity.* While digital media have created vigorous new child and youth markets, new forms of active consumption are emerging in which kids appropriate and re-use mass culture in innovative ways. Some software encourages innovative participation in extending design and experience, or teaches cognitive skills through software and media design activities. Even more striking, kids' own cultural productions can now be distributed nationally and internationally, building new modes and styles of culture largely invisible to the adult world. In sum, the research literature seems to conclude that digital environments are enhancing the expression of kids' imagination in a variety of new and unexpected ways.
3. *Games and gaming.* Games are one of children's earliest experiences with technology, and may be shaping kids' learning habits and technological fluencies; this is the subject of profound debate in the research literature. Relatively little is known about the learning or developmental impact of computer games through the life course, or about the transference of skills from games to other environments. Technologists often view games in terms of multimedia and human-computer interaction, and parents worry about the violent content of many computer games, but from the point of view of learning and development what is novel is that gaming is a social activity: because they are often played in groups; because kids often engage in teaching each other how to play; and most important, kids have developed their own learning cultures parallel to that of the schools – perhaps in contradiction to school pedagogy. Thus inquiry into learning and games must have two dimensions: the characteristics of the game itself, especially multimedia content and interaction; and the learning communities that kids build around gaming.
4. *Digital divides.* Technology alone cannot make a difference; each of these emerging trends is fractured by cultural differences (gender, ethnicity), social inequality (class, school quality), and nationality (infrastructure, economic systems). Kids' experience of the world is stratified in every respect, not just their experience of digital media –by age, class, race, gender, nationality and access to place. The most important variable that is clearly addressed by the literature is *age*; it is clear that kids' of different ages have markedly different cognitive abilities and learning styles, but also different degrees of access to space and technology. With some notable exceptions, there is relatively little recognition of the importance of *social class* or *race* in kids' experience of technology. For example, the literature shows kids using instant

replied. Teens do not perceive chat rooms to be dangerous, and do not tell their parents about contacts with strangers for fear of losing their computer privileges.

messaging to reach out to peers to find support in doing homework and getting advice about problems from them, but these are studies of middle class kids, while disadvantaged kids often do not have access to these tools, or to the learning resources to master their use. There is interesting research on *gender* differences in the use of digital media, particularly about video games and mobile phones. There is relatively little comparative research across *national boundaries*, to some extent because different countries have adopted different technology infrastructures, but studies of cross-national communication by immigrant kids may be a very interesting predictor of the future uses of the global reach of the Internet. And finally, it appears that *place* or *social context* may be very important in shaping disadvantaged kids' experience of digital media, particularly access to public learning places outside of school.

In summarizing the research literature that describes these themes there will be three goals. First, what do we know so far and how do we know it? Secondly, what do we need to learn to understand these phenomena better? Thirdly, how might these experiences be used to design richer learning environments for kids?³

A. Digital divides.⁴

Research on kids' and digital media tends to reflect the priorities of the funding sources. Commercial research tends to focus upon market development and is usually proprietary, although there are also important field experiments to place new technologies in kids' learning spaces.⁵ Federal research about the Internet in the US is focused upon the 'digital divide' in *access* to computers and the Internet, reflecting a national policy

³ Most of the citations in the text come from an annotated bibliographic database funded by this grant. Cited research only illustrates the literature, it is not comprehensive; additional citations are in the literature reviews that are appended.

⁴ See Appendix A. *Children's Access to the Internet*, by Megan Finn.

⁵ The Intel Computer Clubhouse Network is an after-school community-based technology learning program. The Computer Clubhouses provide youth in underserved communities a safe learning environment where they can acquire the tool necessary for personal and professional success. The Club Houses create a "community of learners" where young people work with mentors, and staff to explore their own ideas, develop skills, and build confidence. Intel also supports programs that encourage and facilitate learning through technology for educators. The Intel Teach to the Future program teaches teachers and other educational professionals how to integrate technology into their daily lesson plans, and encourage creativity among their student through the use technology. For older kids pursuing higher education, Microsoft is sponsoring a joint effort with MIT called iCampus. The iCampus projects purposes is to revolutionize higher education with information technology. The project continues to build on MIT's philosophy of "hands-on learning" for a digital era. One of the goals of the iCampus project is to develop creative uses of technology to teach kids difficult mathematic and scientific principles. Another part of the project is the sharing of education content between faculty all over the world using web services technologies.

emphasizing *access*. Studies on *participation* in the use of digital media for learning tend to be funded by private foundations, although there is considerable NSF funding of applications to teach math and science in the schools.⁶ As a consequence, as Livingstone [2003] notes, there are relatively few studies that describe how digital media are changing the learning experiences of kids of different ages, classes and racial ethnicities. Research in the UK, in contrast, is more focused upon participation and learning, with several research programs to identify kids patterns of access and use of the Internet, reflecting a national interest in updating school curricula to include media literacy and to mainstream information technology into school pedagogy.⁷

Where there is qualitative research on participation in learning with digital media, the rapid pace of technological change tends to make research outdated, as one device is replaced by another – yesterday email was new, today it's instant messaging, tomorrow the exchange of images on camera phones. What is lacking is longitudinal research about kids' use of digital media: does the sequence of innovative devices have a cumulative effect on learning strategies and skills? Is the distinction between children's and teenagers' use of digital media a reflection of access, or a reflection of developmental stage; for example, would children use instant messaging on mobile phones in the same manner that teenagers do, if cost were not a factor? Within these limits, however, the research literature contains important findings about the stratification of kids' experience with digital media that bear upon our question about informal learning.

⁶ Important reports on participation in information and communication technologies in the United States include: Roberts, Ulla, Rodeout, Brodie [1999] *Kids and the Media @ the New Millennium*, Kaiser Family Foundation survey of children's computer use; Wartella, O'Keefe & Scantlin [2000] *Children and Interactive Media: A Compendium of Current Research and Directions for the Future*, a review of the impact of media on learning and cognitive development funded by the Markle Foundation; Lenhart, Rainie & Lewis [2001] *Pew Internet Teens Online Report*, a survey of the Internet's impact upon friendships and family relations funded by the Pew Foundation; Ba, Culp, Green, Henriquez & Honey [2001] *Effective Technology Use in Low-Income Communities: Research Review for the America Connects Consortium*, a review of the various dimensions of the digital divide.

⁷ Key reports on the impact of information and communication technologies on kids in the UK include: British Educational Communication and Technology Agency (BECTA), [2001] *Computer Games in Education*; Interactive Education Project [2001, 2003] *Out of School Uses of Technology*, two surveys on out of school uses of technology; Facer, Furlong, Sutherland 2003, *Children and Computing in the Home*; Livingstone 2002, *Children's Use of the Internet: A Literature Review*; Livingstone 2004, *UK Children Go Online*, survey of experiences of young people and their parents; Buckingham, Sefton-Green, Willett 2003, *Shared Spaces: Informal Learning and Digital Culture*; Sefton-Green 2004, *Literature Review in Informal Learning with Technology Outside School*, a NESTA Futurelab study on informal learning using new media, grounded in learning and development theory.

1. *The need for informal public learning resources.* In a study of a community technology center, Clark [2001] concludes that, “the Internet’s potential for increasing social capital and civic engagement may lie less in the technology itself, and more in public locations that enable its use among disadvantaged communities.” All children find Internet access in public institutions such as libraries, museums and community centers, but middle class children also have access to computers and the Internet at home [Woodard & Gridina 2000; Kaiser Family Foundation 2000]. Clark’s suggestion poses an important question: How can the ‘digital divide’ be addressed by the creation of public spaces for participation in informal learning using digital media, such as libraries, museums and community centers? For example, ‘constructivist’ researchers, those who teach learning skills by enabling children to design and construct digital media, have been active in working in disadvantaged communities, as is illustrated by a recent study to teach juvenile offenders [Cavallo, Papert & Stager 2004]. Note also that Clark’s comment is focused upon participation in civic life by those who now feel excluded from it, not just upon learning. That is, kids’ participation in these new digital spaces may predict their future participation in adult forms of public life, for digital media must be centrally concerned with developing kids’ sense of agency, identity, and collaborative production of knowledge.

2. *Access to learning capital.* Children using the technology in public centers are generally from low-income families [Kaiser Family Foundation 2003], and their lack of access to technology and skill using it places them at a fundamental disadvantage in applying computers to complex tasks such as research, email or messaging [Levin & Arafeh 2002]. Access is an issue, for all kids are dependent upon the financial resources necessary to support the provision and use of computers, networks and mobile phones; but while access is necessary it is not sufficient to predict participation [Ba, et al 2001]. Disadvantaged children may have sophisticated knowledge capital relevant to managing the conditions of their daily life, knowledge that is little valued by current educational assessment regimes, but often lack access to the forms of learning capital necessary to participate in the use of new technologies. Research shows that all children tend to overestimate their technical ability, and parents tend to overestimate their children’s skills, thus kids require access to learning resources in order to scaffold mastery of new technical skills. This kind of knowledge capital resides in the peer groups and family members (siblings as well as parents) of middle class kids, making them seem to be independent learners, while disadvantaged kids are much more dependent upon scaffolding by people at supporting institutions such as schools and community centers [Ba et al 2004].

The global reach of the Internet has particular utility for immigrant kids, since it may give them access to knowledge capital that is geographically remote. Lam [2003] describes how Chinese immigrant kids engaged in learning English as a second language find it more useful to converse online with other Chinese students learning English – in Hong Kong or Singapore for example – than face to face with native English speakers. Miller and Slater’s study of Trinidad [2000]

shows how immigrants to America can use the Internet to sustain a sense of intimate connection with family members in Trinidad and in Diaspora around the world. These studies suggest that the scope of online ‘learning communities’ can be international, given common needs and collective expertise.

B. The changing scope and scale of kids’ social worlds.⁸

The mobile phone and the Internet are changing the scale and scope of kids’ worlds -- from small local face-to-face relations to potentially very large technology-mediated social networks that can cross many social boundaries, including age, class and race. These peer-to-peer [P2P] relationships are important new social formations with distinctive cultures, which provide an infrastructure for kids native learning practices and communities.

1. *Kids economies determine the scale and scope of their social networks.* Until they are old enough to own a mobile phone, children use the Internet to develop peer networks -- using lists, chat rooms, web based social software, and email -- because it is free. These communication strategies link kids to peers, but also to parents; the term ‘mobile parenting’ is now used to describe parenting of young children from afar by mobile phone. Teenagers are more likely to be provided mobile phones by their parents for the purpose of coordination or safety, but in fact use text messaging to build distinctive new private spaces and cultures [Ling 2004]. Messaging is significantly cheaper than voice --hence usually messaging is used for peer communication, while voice is used for communication with parents.⁹ Here again, kids’ economies are central: messaging is far cheaper than voice.
2. *Adult regulation.* Adults are concerned about the difficulty in regulating these new private communication spaces [Papadakis 2001]. Children can explore the Internet freely, leading to efforts to develop software to monitor and limit children’s access to obscene web sites, and parental concern that child molesters might use the Internet to contact children. The Children’s Internet Protection Act (CIPA) mandated the use of filtering software in public libraries, to prevent kids from accessing pornography, creating a market for software that enables parents and libraries to monitor children’s computer use [Kaiser 2000]. Interestingly,

⁸ See Appendix B. *Young People and Mobile Phones*, by Alison Billings.

⁹ There are two distinct types of messaging discussed in the literature. There is *text messaging [TM]*, which refers to SMS (Short Message Service) text messages and I-mode messages, which are sent between mobile devices. These text messages are asynchronous. There is also *instant messaging [IM]*, which refers to real time conversations that happen using messaging software on PCs, while people are online. Instant Messaging is synchronous. Both are forms of messaging, but are different. Text messaging is not fixed in a geographically place, existing in virtual spaces that are quite malleable, and text is limited to 160 spaces. Instant messaging is a social interaction that happens in real time, and in a fixed location, because of use of PC platforms.

parents and kids don't generally agree on whether or not there are ground rules for kids' use of certain parts of the Internet, or if they exist, what these rules are [Turow & Nir 2000; Livingstone & Bober 2004].

3. *Personal communication.* Messaging – on the Internet but especially on mobile phones – has created a new sphere of conduct that is private, outside of parental or institutional controls. These private spaces are particularly striking in countries with cultures that regulate behavior closely, such as Japan [Ito 2001, 2003] and the Philippines [Ellwood-Clayton 2003]. In Norway, Proitz [2004] has written about changing notions of intimacy and Ling [2000] about new cultures of time and social coordination [see also Skog 2002]. In the UK, Grintner & Eldridge [2001, 2003] have investigated the content of text messages, which reveal new modes of reputation and social capital.

For example, teens' messaging culture requires the exchange of a 'Good night' message every night at bedtime – "GN" in text messaging code – signifying the closure of the private tacit community that is on call during all waking hours [Grintner & Eldridge 2003]. The 'good night' message being reduced to 'GN' illustrates the abbreviations that are used to save character spaces, because SMS messages are limited to 160 characters. GN is used in non-native English speaking countries to say good night, illustrating the hybrid languages that are being created by SMS around the world.

Several things are important about this development. Firstly, these are *private spaces*, relatively hidden from the normal cultural and institutional controls that govern kids lives, thus are an important sphere for the exercise of an independent sense of agency. Secondly, new ethical and cultural norms are evolving in these spaces; in principle one is interconnected with ones peers at all times, thus text messaging is a kind of meta- conversation that continues in the midst of public spaces and activities – the family, the classroom, and so forth. Thirdly, this is a virtual space where actions do not have the same consequences as in face-to-face spaces; thus there is considerable experimentation with identity and sexual politics [Turkle 1995]. Finally, these social networks are also places where social capital can be built, exchanged, and called upon in problem solving and learning. Exchange is not just social, it also includes building reputation by the production and publication of new media works. However, research indicates that while instant messaging is used for help on homework, it is most commonly used to generate and sustain social relationships [Schiano 2002]. There is little research on this phenomenon in the US. American teenagers are now migrating from computer based email and chat rooms to phone messaging, but children continue to use Internet communications because they are less likely to have access to mobile phones [Quinn, et al 2004].

Much research is focused upon particular devices (e.g., mobile phones) or particular settings (e.g., school), but not the relationships between them. In practice, online private social spaces often overlap with more conventional public

or institutional spaces. Text messages can enter the home or classroom without the phone ringing, thus youth culture often provides a medium for private discussions within public spaces. Similarly, kids playing online collaborative computer games or doing homework alone at home could simultaneously be conducting a text messaging conversation. What is lacking is research on these practices in their natural settings, to understand the kinds of social support and social capital that they generate, and to determine how they might support learning.

4. *A note on gender.* Gender is studied more often than other kinds of social stratification of digital experiences. For example: Although the most important feature of mobile phones to both girls and boys is ease of use, there are differences of opinion about the value of other features. Girls are generally more interested in the social functionality of the mobile phone, while boys are more focused on the device itself and its use as a status symbol [Ling 2001]. In addition, girls are more interested in the design and personalization features of phones, such as ring tones and colored faceplates, while boys are more interested in technical features and device performance [Skog 2002].

C. Technologies of the childhood imagination.

Studies of the impact of television on kids argue that mass culture *is* youth culture, because it created mass audiences that transcend differences of age, class and race, creating a common culture. Today we are far beyond TV, for cultural commodities aimed at kids are branded and packaged in multiple media; thus movies are used to create markets for video games, and other consumables such as clothing, books, videos, etc [Montgomery 2001].

And yet, several lines of research indicate that kids are not simply passive consumers of mass culture, and ICTs have become what Ito [2004] calls ‘the technologies of childhood imagination.’ However, many of these emerging phenomena often reflect the lifestyle of middle class kids who have access to considerable cultural and technical capital, adding urgency to the question of access and scaffolding the learning of disadvantaged kids.

1. *Search and Research.* The World Wide Web, a technology for information retrieval and research, now supports sophisticated database and search facilities like Google and Yahoo!. These technologies have transformed scholarly publishing and libraries, but have they changed kids’ capabilities for independent learning? Balal & Kirby [2002] found that kids confidence in their computer abilities was not an accurate predictor of the accuracy of their fact-finding online searches; only 50% of seventh graders were able to solve information retrieval problems and find correct answers, compared with 90% of graduate students. Children were better at open-ended browsing and exploration than tasks with specific concrete answers. Cooper [2002] found that seven year olds in a school library preferred the computer to print, but were able to navigate print better than online information, and needed adult scaffolding to move from browsing and

- exploration to accurate searching. Young children tend to rely on visual rather than textual cues in online environments; this line of research has been developed in studies of visual literacy. Thus Druin and her colleagues [2003] are developing learning applications to teach children research skills, such a digital library with multimedia information about animals to teach the importance of collaboration.
2. *Active consumption.* A rich line of research regarding kids' consumption of information describes kids' ways of appropriating mass culture to their own purposes. Jenkins [1992, 1998] work on 'fan fiction' points out that technologies of personal communication and online publishing have created rich channels for discussion and analysis of mass culture, and these channels often appropriate themes and characters from movies, television and games and create entirely new narratives for them. Jenkins calls this a 'participatory culture,' distinguished from a passive consumer society. More recently Ito [forthcoming] argues that although in adapting and using commercial games and toys, children engage in genuinely new forms of cultural production. This line of research might well be traced back to Turkle's groundbreaking *The Second Self* [1984] which describes the use of computers from the point of view of psychological development, showing how kids of different ages use computers as a form of identity play, to 'work through' psychological issues [Sutton-Smith 1986]. In this sense, all play is a kind of appropriation of toys, games and tools, and the research question is how to document and describe the way children and teenagers find meaning in the use of digital media. Gender differences have been documented in children's play [Thorne 1993; Vered 1998], but there is still relatively little documentation of how children of different races, classes and ethnicities play with toys – traditional or digital, how they choose among toys in different media, and how they combine different kinds of toys and media in their play. There has been extensive study of *Pokemon*, which might be described as a series of products (video games, card games, etc) that are bought for children, but which in children's hands become objects to play with [Allison 2004, Tobin 2004]. There is also substantial research interest in 'machinima,' the creative use of computer game engines as a medium for fan fiction.
 3. *Alternative distribution.* The creative and culturally productive activities of children and youth – both in their engagements with mass culture and constructionist environments – are increasingly shared and distributed outside of the boundaries of home and school. Kids are publishing knowledge and cultural products in the form of web pages and blogs, thus Abbott [1999] analyzed kids' homepages to discover the new kinds of narratives they are developing online, and boyd [2003] has been analyzing new kinds of narrative and sense of audience in blogging. Further, peer-to-peer distribution and payments systems such as PayPal, auction sites, and file sharing allow these products to be exchanged and monetized in new ways that are only beginning to be understood. In addition to crossing the boundaries of home and school, this flow of information, knowledge and culture also complicates boundaries of age and national identification.

4. *Design and construction.* MIT has been the home of a movement called ‘constructionism,’ defined in opposition to ‘instructionism,’ which argues that students can be motivated to learn by designing and building using computing technologies. Thus Papert [1991] developed ‘Logo,’ a computer language to teach children how to learn mathematics. An important thread of this movement attempts to teach kids by helping them to build computer games, using the motivational factors of games to build self-esteem and skills [Kafai 1995, 1996; Bruckman 1997; Heeter 2003; Robertson & Good 2004]. Notably, game building frequently has been used in inner-city community centers to attract youth who are little motivated by school instruction [Resnick, Ruck & Cooke 1998; Buckingham, Sefton, Green & Willett 2003; Willett 2003; Cavallo, Papert & Stager 2004]. There are also important studies about the use of media design projects in schools [Sinker 2000], and multimedia authoring as a form of narrative construction that engages kids’ imagination [Baecker & Posner 1999].

An important variant on constructivism is the kind of learning that might occur through model construction – building by tinkering in 2D programmable environments or with technologies that have embedded computers (like ‘crickets’), or actually assembling electric/mechanical objects.

Important research themes cross these four paths of investigation into how children and teenagers learn.

- *Motivation* – How and when do kids realize that they are not consumers of culture or learning, but develop a sense of agency to create their own cultures?
- *Narrative construction* – What kinds of narratives and genres are kids creating using ICTs, and what are the significant differences in these new forms of communication, play and creativity among kids of different class, gender, race and ethnicity?
- *Scaffolding* – What kinds of places, teachers, peer formations, and software can help kids of different ages develop their learning skills?

There is still relatively little documentation of kids’ lives in these dimensions, and the research – although promising and very provocative – is not yet cumulative.

D. Games and Gaming.¹⁰

Games are a special case, being children’s most intense experience with technology and an important element of children’s culture. Children most frequently report using the computer to play computer games [Markle 2000; Becker 2000; US Census 2000]. Yet, most of the research on kids’ gaming is proprietary, and relatively little is known about what kids learn from games or the transfer of learning from games to other contexts. Moreover, like other ICT research, much of the published literature is focused upon assessment of new software, and is neither cumulative nor grounded in learning theory or developmental science [although see Gee 2003].

¹⁰ See Appendix C, *Games* by Sarah Ellinger and Dan Perkel.

1. *Social context.* Proprietary research tends to look at game hardware and user interfaces, and critics of computer games tend to look at their content, but by far the most surprising research about computer games concerns the significance of the social contexts in which they are played. Children's use of technology – and significant research has been done about the importance of games in the lives and culture of children under 12 – is highly situated, often in ways that game designers never foresaw, and suggests that the social contexts in which games are played are as important as the content and design of the game. For example:

Multimedia Content. Game narratives have been the subject of close attention by game companies and game designers. Most notably, it appears that boys and girls tend to like very different kinds of narratives – boys liking action, girls liking pattern recognition and relationship building games [Laurel 2003; Salen & Zimmerman, 2004]. Similarly, multimedia simulations are the subject of massive investment by game companies, and analysis by those interested in new media literacy [Kress & van Leeuwen 1996; Gee 2003]. In the UK, this research has been used to investigate new directions for classroom pedagogies [FutureLab 2004].

Gender. Many have commented that the content of computer games reinforces gender stereotyping and argued that for this reason boys play games far more than girls [Vered 1998]. However, Bryce and Rutter [2002] argue that *place* is more important than *content* in making girls comfortable with games; that is, girls like to play games if they are in environments that are not hostile to girls, as many public places are. This finding is consistent with studies of other kinds of software that argue that one cannot analyze the human-computer relation or virtual experiences without looking at the physical places and social relationships within which humans and computers are meeting.

Gamer communities. Even when gamers play in solitary places, they are members of gamer communities [Ducheneaut & Moore 2003], which exchange information about how to play the game ('cheats,' 'tips,' 'mods'), and engage in fan fiction activities discussing the game. These peer formations tend to be gendered; the exception is that sibs are frequent significant participants in teaching younger sibs of both sexes about gaming [Fromme 2003]. Games may also be collaborative rather than solitary activities; among older kids, this discussion often occurs in real time on mobile phones. But networked games (MMORPGs) are designed with social communication and coordination as part of the game experience [Mannheim 2001; Yee 2002].

Family. Younger children typically play games in family settings, if not with parents, then with sibs [Ermi & Mayra 2003; Facer, Furlong, Furlong & Sutherland 2003]. Far more research is focused on computer games than on board games, but families play both; little is known about how gaming affects family dynamics and relationships, particularly families of different social class and

racial ethnicities. Siblings are the most important missing variable in all research about how kids learn to use digital media.

Community Centers. Gaming is a significant magnet for kids' interest in community center activities [Clark 2003], and, many significant experiments with informal learning have been conducted in community centers using constructivist projects to design computer games. In thinking about informal learning in public places, gaming – both games and the learning cultures that surround them – seems to be an important element, given the importance of games in kids' world.

Schools. The British Educational communications and Technology Agency studied seven schools using video games to support classroom instruction [BECTA 2001], concluding that there were educational benefits to gaming (including motivation, agency, self-esteem), but also found significant problems fitting the game experience into classroom order and pedagogy. Danish researchers studied gaming by school children, concluding that the benefits included the development of social networks (i.e., exchange of tips and cheats), and promotion of the imagination [Jessen 1999]. And yet, others note that gaming culture may be causing a fundamental generational conflict with school pedagogies and texts [Prensky 2000, Gros 2003].

2. *Educational benefits of gaming.* Recently there have been systematic attempts to assess the benefits of digital media from the point of view of learning theory and developmental psychology [Wartella, O'Keefe & Scantlin 2000], and to analyze games and gaming within the context of learning and information theory [Prensky 2000; Gee 2003; Kirriemuir & McFarlane 2003]. The research has been focused upon informal learning with commercial games because educational games tend to be unpopular with kids. And yet, Gros [2003] argues that computer games are shaping the learning styles of children creating a generational disconnect between teachers and students.

Greenfield [1984, 1994] has conducted experiments demonstrating that computer games teach information processing skills, including spatial perception skills and narrative creativity, creating the need for media literacy curricula in the schools [Kress 1998]. Greenfield argues that fluency in visual interfaces and the iconic codes of video games can transfer to the use of other technologies, creating a kind of technical literacy. Subrahmanyam & Greenfield [1994] demonstrated that computer games could teach spatial skills to those without them, and improve spatial thinking.

There have been a number of educational software experiments, often funded by the National Science Foundation, to teach science to kids. One such program used mobile games to teach children about animal behavior, but also found that the learning styles associated with games is incompatible with that of schools. Because educational software is often grant funded its development as a product

and distribution is often limited, and thus far shared standards for its assessment have not developed [although see NESTA 2003].

Why games are motivating. The classic theory is that games induce an experience of ‘flow’ in which the gamer loses a sense of time and becomes lost in the activity [Csikszentmihalyi 1990], a theory that has been applied to games in specific ways by Kirriemuir & McFarlane [2003]. Others argue that games increase children’s sense of agency and power and interactivity [Ermi & Mayra 2003, Greenfield 1984]. Other factors relevant to cognitive development include the power of interactivity, and of visual stimulation. But equally important, from the point of view of creating new environments for learning, gaming has an element of transgression of cultural rules, or risk [Goffman 1967]. This is why kids like games with violent imagery, and why they see games and school based education as opposites.

Digital gaming appears to build powerful communities of practice among children and teenagers, but no research has investigated the social benefits of computer games. For example, for children the ability to play together is motivating because it reinforces group membership, but games must provide a context and motivation to work together in a cooperative manner. What has not yet been demonstrated is whether there is transfer of skills and learning styles from gaming to formal or informal learning environments, or, if not transfer, if a complementary pedagogy might be possible.

Given the importance of games and gaming in shaping children’s experience with technology, and – if the advocates are correct – their cognitive skills, substantial research is needed to describe kids gaming cultures.

- How do games and gaming motivate kids? Are these motivational factors transferable to learning?
- How and when do skills transfer from gaming to other contexts?
- What are the long term, longitudinal effects of gaming?
- Is the problem with educational games one of design, or social context?
- What is the relevance of the learning from gaming upon school performance?
- How do children’s developmental stages affect their approach to technology?
- What are the benefits of gaming for the development collaborative and communication skills, and kids’ fluency with information technologies?
- What cultures are growing around mobile gaming devices?
- What design cultures are growing around games (mods, flash, and so on)?

Ethnographic Research and Design Research Opportunities

A continuing thread through this review of the literature has focused upon emergent patterns of behavior that are promising focal points for innovation in informal learning using digital media, but which require additional investigation. This section will briefly summarize those areas.

1. *How do digital media affect kids over the life course?*

There is a need for a longitudinal study of kids' cumulative experience of digital media from childhood through the teen years. Because of the pace of innovation in digital media, this is a rapidly evolving target, yet a rich description of kids' memories of how and what they learned from digital media would provide a baseline for further research as well as design work.

2. *Digital Divides.*

How do kids of different social classes, racial ethnicities and gender experience digital media? What are the similarities and differences in modes of participation of digital media?

How can digital media be used for informal learning in new kinds of public places, such as computer clubs? What is the relationship between informal learning in community centers and learning in school, from kids' perspective?

3. *Mobile communication networks are changing the scale, scope and dynamics of kids' social world.*

How do kids create and sustain new private social worlds using digital media such as instant messaging and blogs? How do these cultures overlap with and affect institutions such as families and schools?

How do kids use communication networks to build social capital and share knowledge?

How do the emergent technologies of handheld communication and information retrieval devices change kids' access to social membership and learning. What are the broader implications of pervasive 'always on' access for how kids experience information, imagination and social networks? Will handhelds affect access and participation, and will this change the dynamics of the digital divides?

How does the Internet change the way kids search for information and do research-like activities?

How does the global reach of the Internet affect kids' learning, if it does? What does the use of the Internet by immigrant kids teach us about this?

4. *Technologies of the imagination.*

How are digital media enabling kids to participate in mass culture in new ways, such as fan fiction?

How are digital media empowering kids to create new kinds of cultural narratives, such as instant messaging, blogs, multimedia, and so forth?

How are digital tools enabling kids to create new kinds of cultural products such as online journals, ‘mashups’, game ‘mods’, amateur comics, and fan fiction? How do kids use the Internet based peer to peer sites for publication, distribution and trading, thereby creating reputations through their digital productions?

5. Games and Gaming.

What kinds of learning communities do kids build around gaming? Are these modes of learning applicable to informal learning?

What do kids learn from games, and how do games with different kinds of content and multimedia interactions affect kids’ learning practices in other contexts?

How are digital authority tools enabling kids to create new kinds of cultural products such as online journals, ‘mashups’, game ‘mods’, amateur comics and fan fiction? How do kids use Internet based peer-to-peer publication, distribution and trading sites to distribute, interact, and create reputations?

Design constraints within digital technologies and media are an important hidden variable in the research literature. Many of the findings about learning and digital media were conducted using technologies that are not optimized for learning, but could be. Secondly, many of the most exciting interventions involve empowering kids to design new media and new narratives, not just to consume them as found. Thus there are opportunities to gain valuable insights through *design research* tailored to complement and stimulate the ethnographic investigations. To summarize these opportunities we return to our key themes, here briefly restated with illustrations of possible design research opportunities.

1. *How do digital media affect kids over the life course?*

A longitudinal study should identify the key points in childhood’s course where design intervention might stimulate significant learning results.

2. *Digital Divides.*

It may well be possible to nurture more participation among disadvantaged kids by extending the design of mobile phones and/or public computer access. Working with vendors to create more robust information displays for mobile phones might serve to enrich participation. Similarly, building activities that involve intermittent web access to enrich kids’ experience could be tested in classroom and computer club settings to make them a better resource.

Technology firms such as Intel, HP and Nokia are likely to be interested in partnering in optimizing everyday digital technologies for informal learning, as well as developing digital media for informal learning in community centers they now support.

3. *Communication networks are changing the scale, scope and dynamics of kids' social world.*

Designing learning assignments that require disciplined communication and collaboration using new digital social spaces could help determine how best to bring informal and school learning into a complementary relation.

4. *Technologies of the imagination.*

Storytelling activities could provide both an incentive and direction in forming richer narrative structures that might allow kids to participate more fully in using digital media for expression, communication and publication of their works.

5. *Games and Gaming.*

Design challenges which could link private virtual groups with larger, more diverse cohorts could point the way to allowing kids to solve problems more effectively and develop a more critical view of brokered information in a manner similar to the way in which pervasive games have involved large populations in civic activities.