Developing Minds with Digital Media:
Habits of Mind in the YouTube Era
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November 2007

ACKNOWLEDGEMENTS

SECTION I: COGNITIVE DEVELOPMENT OVERVIEW

SECTION II: YOUTH NDM BEHAVIORS IN AND (MOSTLY) OUT OF SCHOOL

SECTION III: NDM SKILLS AND COGNITIVE DEVELOMENT

INTRODUCTION/ABSTRACT

Children, it seems, are born these days consuming media. More children are being exposed to more new digital media (NDM) at younger ages than ever before. According to a 2005 study by the Kaiser Family Foundation, 48% of American children six and under were active computer users, 91% watched TV, and 89% watched videos or DVDs (Rideout, 2003). Research also indicates that by age 7, many of these young computer users are active users on networked gaming sites ("Club Penguin-FAQs", http://www.clubpenguin.com/help/frequently_asked_questions.html). By the time s/he reaches the age of 18, the average American youngster is consuming a varied diet of media, from TV and DVDs to podcasts, producing some media work of his or her own, and using technologies like texting and social networking sites to stay in touch with friends and family. A Kaiser Family Foundation study from 1999 states that, "[l]iterally, hundreds of empirical studies conducted over the past half century leave little doubt that, given exposure, media content can and does influence youngster's beliefs, attitudes and behaviors" (Roberts, 1999). There is the sense that children are maturing faster, and achieving more at younger ages. Is this phenomenon related to NDM?

The internet was originally designed to function as a communications portal among a small, closed set of government professionals. Now it is a vast, unregulated network available to anyone with access to the right hardware. No one really knows how large the internet is, or what information it's hosting at any given time. The internet is always on, always available, and always ready to play a game, view a video or connect a user to a network of friends and communities. It also allows a user to download materials, illegally or otherwise, post nasty comments, anonymously harass or mislead other users, and engage in a host of similar transgressions ranging from minor infractions to critical violations. It can also provide a user with virtually limitless opportunities for self-directed learning, connecting with like-minded communities, engaging with entertainment and creative interests, and transcending the limitations of home and school.

Much has been said about children and media use, but do media, and specifically NDM, affect how children and adolescents develop cognitively? In this paper we investigate the intersection of classic and contemporary theories of cognitive development, and map a broader cultural paradigm shift relating to cognitive development and new digital media. We follow with an exploration of how the new digital media operate within these respective models, and outline some of the possible long-term implications of young people's persistent engagement with the NDM. For instance, Piaget's theories of cognitive development emphasize that a child learns through exploring a three dimensional world: what happens to

learning when the child engages instead with a compelling 2D world comprised of computer code and mediated through a flat screen? Vygotsky's theories of cognitive development suggest that the child and his learning are cultural constructions: what are the cognitive implications of a child living, playing and learning in a highly mediated world?

To explore these questions, we take a close look at the distinctive characteristics of new digital media and at the way in which young people are engaging with these media. In Section II, we assess young people's media use from survey data collected by the Pew Internet and American Life Project, the Kaiser Family Foundation Project, the Bertelsman and Milken Foundations, and various public, academic and corporate entities. We then break down these behaviors to identify how they might introduce and reinforce new cultural symbols and how each behavior compares to its earlier, non-digital instantiation. Our analyses suggest that young people are engaging with NDM in classrooms and in informal settings outside of the classroom, and even in the home; that they enthusiastically engage in extracurricular NDM pursuits; and that these pursuits are largely unmonitored by adults or mentors. In Section III, we analyze the documented NDM practices of Section II into two broad categories — how children produce and find NDM materials, and how they manage NDM information once they have it. Acknowledging the lack of data on the cognitive impacts of these practices, we suggest some possible implications.

Finally, we conclude with thoughts for future study and consideration. What are some of the methodological issues that will need to be addressed in order to answer the questions we've identified? What are some of the lingering cultural issues around NDM use that stubbornly resist interventions? And do digital youth actually differ significantly from their parents? We hope that this paper and subsequent project research will further our understanding of cognitive development and digital media and will guide future cultural conversations, research, and interventions related to children.

Research Parameters

As we focus on how NDM relates to cognitive development, we reluctantly eliminate considerations of other, related spheres, such as morality, ethics, sociality, and aesthetics. Human beings are complicated, integrated organisms; separating out developmental elements at the expense of other competencies will necessarily result in an incomplete picture of children and cognition. However, we hope to be able to address these additional elements at a later date as we proceed with our research.

This paper also does not address how computer interfaces in a broader sense can function as prosthetic

extensions of brain power impacting human cognition. The work of neurologist Antonio Battro, educator Seymour Papert and others has demonstrated the computer's ability to extend brain function, allowing deaf children to 'hear' music, children who'd undergone radical brain surgery to cultivate surprising skills, and children with cerebral palsy to communicate with the outside world. The work of these pioneers in the field of brain/computer interface shows how computers can dramatically alter brain functioning and facilitate communication, but these stories tell us less about the typical young person's experience. Our focus here is on how the NDM impact on cognition by way of affecting habits of mind, or how we think. Brain function is of course fundamental to any discussion of the mind, and references to neurological issues periodically surface throughout this paper. We acknowledge the importance of the brain in relation to cognition and draw upon relevant neurological studies to highlight the brain's capacities and limitations, but we position the brain as the vehicle which facilitates the processes of the mind, and not the facilitator per se.

At the root of our analysis is the concept that the new digital media can be broadly regarded as a new object of cognition. The internet, for example, is something new for young people to understand and engage with, but it is "neither a concrete artifact nor a visible social partner, but a gigantic virtual complex network of networks" (Greenfield and Yan, 2006, p. 393). Studying how children think about the NDM and engage with them can deepen our understanding of conceptual development in general, as well as our understanding of how children engage with and relate to a critical influence in their lives.

We begin our research by reviewing the fields of cognitive development and new digital media. In general, cognitive development is shifting towards theories that acknowledge the important of a child's cultural environment. This section provides a general introduction to cognitive development theory, beginning with a brief overview of Piaget's classic operational stages and an examination of children's media habits and competencies at different ages. We then introduce some of Vygotsky's ideas, and suggest connections between the NDM and cultural changes. Finally, we review past intersections of media and cognitive development and extrapolate guidelines for proceeding with our own research.

SECTION I

COGNITIVE DEVELOPMENT OVERVIEW

Cognitive Development — Definition

Cognitive development is the science of how humans acquire a "mental toolkit" or "habits of mind" for thinking, including the processes of remembering, problem solving, pattern identification, and decision-making.

Cognition refers broadly to how we come to know or understand things. The current study of cognition embraces a wide range of topics, from the basic characteristics that make us human (how we learn language, how we recognize objects and people, how we pay attention) to more highly complex examples of human thought (how we form concepts, how we make moral and ethical decisions, and how we plan and strategize). "Cognitive development" refers specifically to the development of cognition over the lifespan, as opposed to the physical, emotional, or psychodynamic development that also occurs throughout a lifetime.

However, the distinctions between cognition and other areas can be blurry. Emotions, for instance, can influence thoughts. Cognitive development is also influenced by physical health, significant social relationships, mental health and other factors. Nevertheless, in this paper we focus on cognitive development—the development of thinking, understanding, and knowing over a child's life—and how the new digital media may impact it.

Foundations of Cognitive Development Theory

In the following sections, we compare the cognitive development theories of the twentieth century's leading scholars in the field, Jean Piaget and Lev Vygotsky.

Stage theories of child development

A simple way to interpret children's cognitive skills is to look at how they are less than adults—less coordinated, less articulate, less able to control their impulses—and how they grow to be more like adults

over time. Only by closely analyzing how the behaviors, capacities, and tendencies of children differ from those of adults can we gain access into how their minds must differ. For example, Piaget knew that he, and all the adults he knew, easily agreed that the same amount of liquid in a small, thin beaker was present even after it had been poured into a short, fat beaker. Only by asking children—who surprisingly, did not know this—could Piaget begin to understand that children must indeed think differently than adults. Close investigation of such behavioral limitations reveals different cognitive structures.

Following is a concise summary of Piaget's developmental stages (from Siegler and Alibali, 2005):

1. Sensory-motor. Ages 0-2. Infants and toddlers in this period begin with simple reflexes like sucking and grasping and gradually learn to coordinate these reflexes into more complex chains of behavior, like reaching for a desired object. A notable attainment in this period is *object permanence*, where an infant will continue to look for an object after it has been hidden.

2. Pre-operational. Ages 2-7. Children in this period gain the ability to use symbolic representations of the world such as images and language. However, they are limited by their *egocentricity*, whereby they have difficulty taking on perspectives other than their own. Children in this period fail in Piaget's classic conservation task mentioned above. Children focus on the apparent visual difference, or only one aspect of the beaker (height, rather than width), and claim the amount had [has] changed.

3. Concrete operational. Ages 7-11. Children in this period acquire what Piaget calls "operations," or internal representations of a reversible transformation. In other words, the child can imagine changing something and changing it back, such as pouring the water back into the tall, thin beaker in the conservation experiment. For Piaget, operations such as these are the foundations of future logical thought. However, children in this period still struggle with systematic, strategic thinking and abstractions.

4. Formal operational. Ages 11+. This period is widely concerned [considered] the "crowing achievement" of cognitive development, because it allows fully abstract thought, rigorous logic, and scientific hypothesis testing. It must be noted, however, that depending on the domain, many adults do not achieve formal operational reasoning, and that there may be types of reasoning beyond formal operations as well.

Focusing on children's capacities and how they change can result in rich descriptions of what children can and cannot do at each age. Limitations and growth models have taken several theoretical orientations and areas of focus, from a Piagetian stance to information processing models, focusing on topics as disparate as children's developing memory and attention, perception, language use, or social behavior. In order to present an outline of children's developmental limitations and how they may relate to NDM, we've synthesized information related to children's cognitive capabilities organized by age. This overview is meant to be an introduction to child development and children's current media usage for readers less familiar with the field.

Infants and toddlers (0-2)

Historically, the dominant conception of the preverbal child could be best characterized by William James' oft-quoted (and likely oft-misunderstood) assertion "The baby, assailed by eye, ear, nose, skin and entrails at once, feels it all as one great blooming, buzzing confusion" (James, 1890, p. 488; cited in Dember, 1990). Young infants were defined solely by their limitations, conceived of as capable of very little, the consummate blank slate for the world to write on. However, a research movement often called "the competent baby perspective" has focused on the many skills that infants are born with, or acquire at an extremely young age. This research characterizes infants as active participants in life, focusing their attention on preferred stimuli and eliciting specific behaviors from care-givers. For example, research has shown that babies consistently prefer looking at faces vs. non-face stimuli (Cassia, Kuefner, Westerlund, and Nelson, 2006). Babies actively pursue this preference; in turn, their caregivers respond to their gaze with attention and, typically, speech, giving them valuable experience with the language of the culture.

These intriguing findings about the competence of very young babies have impacted the media industry. The success of the "Baby Einstein" series of videos is an industry fairy tale, growing from a basement start-up to selling to Disney for a reported $25 million (Mook, 2002). The company offers DVDs for children as young as 3 months ("Official Baby Einstein DVD Site", http://disney.go.com/disneyvideos/ preschool/babyeinstein/.), well before the American Academy of Pediatricians recommended TV viewing age of 2 years old (Rideout, Vandewater, and Wartella, 2003). Very young children are unlikely to understand television as a recording played through a device. Instead, they are more likely to understand it as a 'magic window' through which one can peer into something happening elsewhere (Potter, 1998). But while infants are likely to perceive TV as something akin to real-life, a recent heavily-publicized study found that DVDs do not substitute for human interaction. Infants' exposure to DVDs like the "Baby Einstein" series was linked to poorer communicative development, even after socio-economic status and

parental education were factored out (Zimmerman, Christakis, and Meltzoff, 2007). The study was not a randomized, experimental trial, so the direction of causation cannot be determined: parents may be buying the tapes because of their child's already poor language skills. Nonetheless, this intriguing finding certainly suggests more research into video time for young children—particularly an investigation into which experiences the child is missing by spending time with the television—is warranted.

A recent Kaiser Family Foundation study found that 59% of American children under the age of two watch television and 42% watch a video or DVD, but only 5% use a computer and 3% play videogames (Rideout, Vandewater, and Wartella, 2003, p. 5). Due to their limited motor function, very young infants will have limited ability to engage with digital media outside of TV and music, since the interfaces currently available (e.g. keyboard and mouse) are not suited to their capacities. However, as digital media becomes hybridized and as traditional toys like stuffed animals and books come with computer chips, it is likely that very young children will have more exposure to NDM. Their favorite teddy bear might come pre-equipped with artificial intelligence and a wireless modem.

Pre-schoolers (3- 5)

Developing motor control allows pre-schoolers access to more forms of digital media. Of the four- to six-year-olds surveyed by the Kaiser Foundation, 70% have used computers and 50% have played video games, and most have begun to exert more control and choice over their patterns of TV and music consumption (Rideout, Vandewater, and Wartella, 2003). Children in this age group experience a great increase in verbal abilities, a burgeoning ability to use symbols in imaginary play, and a rapid increase in short-term memory and information processing capacity (Siegler and Alibali, 2005). Psychologist and media consultant Mimi Baumgarten notes that these characteristics mean that preschool children are drawn to digital media that allow them to experience "opportunities for learning, mastery, and silly fun," particularly through stories featuring "familiar and attractive characters" (2003, p. 3).

Pre-schoolers' computer and game console use is likely to be limited by their somewhat short attention span, easy frustration with "bugs" or other technological hurdles, and lack of or limited reading skills (Baumgarten, 2003). However, as technology improves and more and more products are made available for pre-reading children, these limitations will become less important, especially when the products are designed with pre-schoolers and their different ways of thinking in mind.

For a quick example, pre-operational preschool-age children are known to be "egocentric," or unable to

easily understand other's perspectives. Parents have probably witnessed this in the "parallel conversations" very young children can have, where each party speaks in turn, but with very little actual give-and-take between them. Each child says what he wants to, almost unaffected by what the other child is saying (Siegler and Alibali, 2005). It may be tempting to turn this finding into a blanket prescription such as "young children are egocentric" and therefore assume digital media designed for young children must reflect this egocentric perspective. However, young children are not completely egocentric; when children of this age are asked to show their artwork to a person across the room, they know to show the painted side of the paper, rather than the blank side, as a completely egocentric person might. Digital media producers can instead design media for young children with the awareness of their tendency towards egocentricity and focus on what skills they do have.

Children's understanding of digital representation also changes during this age span. Three-year-olds will assert that a bowl of popcorn shown on a TV screen or photograph will spill if the TV or photo is flipped upside-down (Flavell, Flavell, Green, and Korfmacher, 1990, cited in Wright et al., 1994). Four-year-olds do not, suggesting they have begun to understand that what's seen on television isn't really there. However, there is still a finer distinction to be made: in the unreal world of television, which representations represent real things (live action) and which represent unreal things (cartoons or special effects) and, among those, which represent the factual (live action news or documentaries) and the non-factual (live action sitcoms)? Research has shown that children gradually develop the ability to discern real from nonreal and factual from nonfactual from about ages 3 - 8, with 3-5 year-olds still struggling with many aspects of virtual representation (Wright, et al., 1994). However, little research has yet been done on whether this developmental sequence that unfolds for television remains the same for other forms of digital media.

Early elementary (6-10; 1st - 4th grade)

On average, American children who are 8-10 years old spend about an hour a day playing video games, an hour listening to music, and 3 hours watching TV (Rideout, Vandewater, and Wartella, 2003). Computer use goes up from about ten minutes a day in ages 0-6 to about half an hour a day (Rideout, Vandewater, and Wartella, 2003). As early elementary students learn to read and to engage with print media, the amount of digital media they have access to dramatically widens, perhaps explaining their increased computer use. As their reading improves, it's fair to assume that early elementary students engage with print material in the same ways as older children, but that they often still struggle with conceptual understanding and literacy skills (Snow, Burns, and Griffin, 1998).

As they enter Piaget's concrete operational stage, early elementary students gain many cognitive competencies that pre-schoolers lacked. Where pre-schoolers can typically only cognitively represent static states, older children at the concrete operation stage can represent transformations as well. They easily pass Piaget's classic conservation task, and can begin to understand mathematical transformations like 2 + 3 = 5 and 5 - 3 = 2. Baumgarten notes that children's "growing ability to reason logically gives them the opportunity to take part in strategy-based activities and contests," such as the video games that those in this age group are increasingly using (Baumgarten, 2003; Rideout, Vadewater, and Wartella, 2003).

Early elementary children also begin to develop stronger attention strategies. For example, in comparing two pictures, they begin to scan for information in a systematic way, such as in rows or columns, rather than in an almost-random zigzag pattern (Siegler and Alibali, 2005). This enhanced capacity for sustained attention may also account for increased media use. Young children's understanding of virtual representation also continues to increase. By age seven, most children can discriminate between fact-based programs like the news and fictional programming (Wright, et al., 1994).

Late elementary/ junior high (10-14; 5th - 8th grade)

In late elementary school and junior high, children typically transition into formal operational thinking, developing the capacity to handle abstractions, scientific thinking, and hypothetical scenarios (Siegler and Alibali, 2005). Academic work becomes correspondingly more challenging, and there is an increasing use of the internet to support academic work (Guinee, 2004). According to a Kaiser Family Foundation study, 11- to 14-year-olds in the US spend about an hour a day playing video games, over an hour and a half listening to music, three hours watching TV, and an hour using the computer (up from half an hour in the younger age group) (Roberts, Foehr, and Rideout, 2005).

Baumgarten notes that by this age, "youngsters have garnered the cognitive power and manipulative skills to employ all aspects of internet programs and products at will" and have gained the "capability and patience to trouble-shoot when necessary" (Baumgarten, 2003, p. 8). In other words, little outside of reading level prevents children in this age group from fully utilizing the websites they visit. Junior high school students' understanding of television is approximately at adult levels, but their understanding of another form of digital representation—the internet—is still in development. Children in this age group are likely to make a major shift in their conceptual understanding of the Internet's technical and social

complexity. A recent study showed that by grades 5 and 6, children have reached an adult level of understanding of the technical complexity of the Internet (how computers link to and communicate with one another) (Yan, 2006). But understanding of the Net's social complexity (the various players behind the websites, with their various emotional, political, and financial motivations) comes later—not until grades 7 and 8 (Yan, 2006).

High School (15-18; 9th - 12th grade)

On average, American teens aged 15-18 spend 30 minutes a day playing video games, nearly two and a half hours listening to music, almost an hour and a half using the computer, and roughly two and half hours watching TV (Roberts, Foehr, and Rideout, 2005). This reflects a decrease in time spent playing video games and watching television. Internet use is highest in this age range, compared with children aged 5-14 (DeBell and Chapman, 2003). High school students are capable of fully utilizing NDM motorically and cognitively, and in most cases are able to access NDM financially and physically. But high-schoolers are still developing in many ways: attention, judgment, morals and ethics, emotions, sexuality, and so on. High-schoolers have many cognitive faculties on par with adults, but judgment and discernment may not be—prompting some school systems to implement Internet safety courses (Hochberg, 2007). Such courses often focus on the perceived "stranger danger" of the social network sites that are so popular in this age range—a recent Pew study reports that 55% of teens that go online have a profile at sites like MySpace, Xanga, and so on (Lenhart and Madden, 2007).

Vygotsky, cognitive development and culture

Around the same time that Piaget was developing his theories of child development, Lev Vygotsky was studying children's thinking in the USSR, with a particular focus on the influence of culture. Although born in the same year as Piaget, Vygotsky died much younger, and many of his works were only translated much later—the influential *Mind in Society* was finally translated into English in 1978.

Piaget and Vygotsky both acknowledge the importance of the external world in child development but differ in their formulations of how these factors are processed by young minds. Piaget saw the developing child as a 'little scientist' whose engagement with the physical world was guided by his internal capacities for learning. In contrast, Vygotsky positioned the child within a web of culture and suggested that cognition was the product of that culture. For Vygotsky, cultural symbols and artifacts were fundamental in determining both what a child learns and how s/he learns it.

Where Piaget saw isolated "little scientists" working and re-working on concrete objects in the world at their own pace, Vygotsky focused on dynamic external relationships that shape a child's thinking. In particular, he focused on what he called the zone of proximal development, the space between a child's capacities when working alone and when working with the support of another: a parent, a more advanced peer, or perhaps—as this paper will explore—a machine.

Cognitive theorists since Piaget have noted the important role that cultural transmission plays in shaping our cognitive apparatus. Culturally accrued knowledge is passed down in the form of cultural artifacts and linguistic symbols, which can be internalized as cognitive representations. Task repetition results in an internalization of representations over time, transforming a casual tool into a cognitive one. For instance, the concept of numbers was once external to our minds, a way of thinking that stood in stark contrast to our native, internal representations (Dehaene, 1997). But as we repeatedly use numbers, we gradually internalized their meaning, so that '7', both the lines and the concept, came to mean something internally. This process of internalizing cultural tools has accounted for sweeping changes in entire cultures (such as a pre-literate society becoming literate) as well as microdevelopmental changes within an individual child. The study of how these symbols are internalized and how they influence (indeed, constitute) our habits of mind is the foundation of the psychological discipline of human development, and also of the study of media ecology.

These symbolic representations and discourses of our culture powerfully shape not just what we think about, but how we think. As psychologist Michael Tomasello notes, the processes of cultural learning "have done the actual work of creating many, if not all, of the most distinctive and important cognitive products and processes of the species *Homo sapiens*" (Tomasello, 1999, p. 11). Past cultural innovations such as symbol use and writing have deeply shaped the cognition of every human exposed to them (Olson, 1995; Wolf, 2007).

Cultural theorist Raymond Williams speaks of ebbs and flows in the influence of different technologies; he proposes an ecological model where, at any point in time, certain media models are fading, others are dominant, and still others are emergent. At the present time, digital media are considered emergent media and are likely to ascend to dominance within our lifetimes, overtaking print, mass media and older oral practices. Language and literacy skills are necessary to engage online successfully — to communicate, to argue, to share one's thoughts— and will likely continue to be. Text-based literacy may have restructured the human brain in a beneficial way, but that doesn't preclude the possibility that other literacies can have

the same or similar effect. Given the extent to which text-based literacy has impacted human cognition, the current environment of novel visual and digital representations —where text is digitized, where video is streaming, portable and on demand, where screens are 'nervous,' where intimate friends can be on the other side of the world, and where media content itself is created to a growing extent by fans and amateurs — is likely having a similar transformative impact on developing minds.

NDM may also impact developing minds in many possible ways. Studying NDM as tools means asking what NDM allow children to accomplish, what cultural norms are associated with their use, and how repeated use of NDM may affect how children subsequently think. But NDM are more than tools. They can also function as extensions of brainpower, offering the user a way to expand his intelligence both practically and cognitively. Computers can also operate as Vygotskian scaffolds, prodding and inspiring children to accomplish tasks beyond their pen ability levels. New digital media are also a handy delivery vector for our other great human cultural tools (e.g. discourses, methodologies, disciplines, and notational systems). In short, NDM are powerful instruments which both convey cultural symbols and embody them.

The emergence of extended neuroplasticity, and a new conceptual model

The discipline of psychology, like many disciplines, has a longstanding tradition of interpreting media through the lens of the psychological theory in vogue at the time. Early cinema, for instance, provided Freudians of the time with rich visual metaphors to psychoanalyze, and early television was seen as a one-way communications device in a behaviorist operant conditioning scheme (Skinner, 1953/2005). Most mainstream definitions of cognitive development offer Piaget's four developmental stages as accepted truth. But while Piaget's theories are still valuable, the world that Piaget knew is quite different from the one we live in today; advances in neuroscience, coupled with the NDM, suggest that the mainstream paradigm for understanding human cognition needs to be reexamined.

Since mid-century, the metaphor of the brain as a machine — a dedicated computing device with irreplaceable parts each dedicated to specific functions — has remained the dominant paradigm. Post-Piagetian psychologists such Bruner attempted to extend the window of neuroplasticity, the ability of the brain to change and adapt from new experiences, throughout adulthood. However, the framing of brain as machine has been decisively challenged by recent findings from the field of neuroscience. Neuroplasticity research conducted within the last decade increasingly proves that the brain is a resilient instrument able to adapt to trauma, new situations and new information. A 2003 study found that senior citizens over 75

who engaged in activities such as dancing, reading or playing games or musical instruments lowered their risk of dementia ("Calisthenics for the Older Mind, on the Home Computer", http://www.nytimes.com/2007/08/26/business/yourmoney/26games.html). This summer saw the publication of Norman Doidge's book *The Brain That Changes Itself*, which chronicles stories of brain-injured patients not only responding well to treatment, but having their brains subsequently retrained to compensate for earlier injuries. In the publication *Half a Brain is Enough*, the Brazilian neuroscientist Antonio Battro recounts the story of Nico, a young boy who has the right side of his brain removed in order to prevent debilitating epileptic seizures. Battro notes that many of Nico's right hemisphere skills subsequently migrated to the left side of his brain, and the boy evinces mathematics, visual arts, and music skills through NDM tools (Battro, 2000). These and similar accounts suggest that the brain behaves less like a well-oiled machine and more like an enterprising mass capable of adapting to changes in brain structure and in one's environment, and that development is a lifelong process which may slow, but does not stop, as we age. They also suggest that computers and the internet are capable of extending brain function.

Responding to evolving demands of work and play

Emerging evidence of an extended period of brain plasticity dovetails nicely with today's sociocultural demands for lifelong learning. The foundation of our capital-driven economy has essentially eliminated assurances of steady employment as organizations downsize, reorganize and streamline their operations. More than ever, an individual will be required to master new media technologies and related behaviors throughout a lifetime. A theory of extended neuroplasticity, in turn, supports the demands of a culture that requires one to constantly learn, synthesize and adjust to external marketplace demands throughout one's lifetime. "[A] capacity for independent learning," suggests NDM guru John Seeley-Brown, "is essential to [students'] future well-being, since they are likely to have multiple careers and will need to continually learn new skills they were not taught in college" (Seeley-Brown, 2007, p. 18).

New digital media are crucial for satisfying this growing need to provide individuals with the tools to teach themselves what they need to know at regular intervals throughout their lifetimes. Self-education through NDM is critical for both young people and adults in a changing world. The internet, in particular, provides children with a way to explore interests, ideas, and friendships that might otherwise be constricted by limits imposed by adults. And though the theory of constructivism harkens back to Piaget, it finds a natural companion in the unstructured, unsupervised, and information-rich internet within a system that may be incapable of handling the growing educational needs of the population.

Play, a difficult term to define on a good day, is nevertheless considered a critical component in childhood development by Piaget, Vygotsky, Jung, Freud, James, and others. As part of the iterative cycle of exploration and learning, play has traditionally been credited with facilitating many important experiences for children, including experimenting with social roles (mommy, baby, etc.) and emotional reactions (happy, sad, angry, etc.), learning about pretense and other people's minds, performing actions on materials in the world, learning behaviors that are adaptive to the environment, and developing language, problem solving, imagination, mimicry, judgment and reasoning skills (Goldstein, 1994; Harris, 2000; Pellegrini, Dupuis, and Smith, 2007).

Play in pre-NDM twentieth century America was characterized by adult advances in the longstanding battle between adult and child conceptions of appropriate play. This period saw a rise in play time (as well as a rise in formal schooling), and the introduction of educational, child-centric toys, dedicated play spaces and 'directed play' designed to control children and counteract the potentially corrosive effects of movies, radio and other media temptations (Chudacoff, 2007). This period also saw a rise in toys tied to celebrities or TV and cartoon characters. Today, the desire to shelter and monitor children's activities has resulted in more home-based children's activities, often involving the computer or television set (Chudacoff, 2007, pp. 216-7). In a related development, the video game industry has become one of the more vibrant, growth-oriented sectors in the world economy (topping more than one billion dollars in June 2007 alone) ("US video game sales raise 31 percent in June," http://news.com.com/U.S.+video+game+sales+rise+31+percent+in+June/2100-1043_3-6198386.html).

Some educators are bemoaning the decline of "third spaces" of play for children such as playgrounds or unsupervised play spaces (Heegan, 2006). They suggest that recreational NDM practices are stripping play of its creative, unstructured elements and subjecting it to restrictions imposed by technological boundaries or inflexible rules. Parents continue to react to fears of child abductions and 'stranger danger'; offline, these fears manifest in rules again children walking outside or engaging in recreational activities without parental supervision (Miles, 2007). Online, they manifest in attempts to block certain sites and monitor a child's media diet.

Online, one can talk to friends, play a game, write a letter, organize the family photo album, and compose music on the same appliance used by a parent to balance spreadsheets, write grant applications, and convene a staff meeting. Online sites such as Games with a Purpose (http://www.gwap.com), Wikipedia, iStockPhoto and InnoCentrive that parlay work into a game or contest suggest that children are hungry for meaningful and engaging activities involving others and are willing to offer their time and talents for free,

even if that activity was once a paying job for someone. In her book *Life on the Screen: Identity in the Age of the Internet*, MIT scholar Sherry Turkle speaks of how our computers hold the artifacts which determine our personal identities (Turkle, 1995); what might it mean that much of contemporary play is tethered to computer hardware and software systems designed for commercial and business purposes?

Another element of online play which differs markedly from past instantiations is the ubiquity and subtlety of commercial advertisements. Youth online are represented as empowered and in charge, but also as vulnerable commercial targets (Buckingham, 2003; Henning, 2007), with children and corporations seemingly locked into a symbiotic relationship online. Forrester research reports that teens accept paid commercial content and proactive solicitations with a shrug (Lui, 2007). To what extent is paid content naturalized and indistinguishable from other content online for these online youth? And what is gained and what is lost when work becomes play, and when play migrates from playgrounds to platforms, requires electricity and Wifi, and features disembodied playmates?

Current research on computers, play, cognition and development is limited, focusing on how best to design educational computer activities for children in a formal school setting (Baumgarten, 2003; Robertson and Goode 2005), and underplaying the significance of recreational NDM use. How do new digital media engage with developmental psychology? Children's engagement with media has often been a contentious issue.

Moral Panics and Media Engagement

While young people's exposure to inappropriate content has been a major concern for media effects researchers, children have been exposed to questionable subject matter in varying degrees throughout modern history. A longstanding tension continues between a child's education via sanctioned institutions (school, church, and home) versus the informal, unsupervised education s/he receive elsewhere (the schoolyard, the street, the internet). Much of this tension comes from the idea that malleable young minds are consuming symbols and text — such as violent or oversexualized content — that are harmful to their development. Distress around the potential corruption of the moral fiber of young minds is so prevalent it has its own term: moral panic. Moral panics around youth ingesting new media forms are evident throughout modern history, from pulp novels (Denning, 1998), popular magazines (Garvey, 1995), early electronic billboards in Times Square (Weigel, 2002), and comic books (Thrasher, 1949), to nickelodeons (Uricchio, 1997), and the sci-fi pulp fiction of the 1930s (Center, 1936). More recently, panics have

centered on the broadcast media forms of radio and TV (Douglas, 1989), with a particular emphasis on violent and sleazy content (Dennis, 1998; Roberts, 1999; Seiner, 1963).

Moral panics continue today around an array of NDM-based games, applications, social networking sites, and blogs. "There is a problem we will have with a new generation of children — who play computer games — that we have never seen before," opines a neurologist on the consumer site About.com. "The implications are very serious for an increasingly violent society and these students will be doing more and more bad things if they are playing games and not doing other things like reading aloud or learning arithmetic" ("Heavy Video Game Use by Kids May slow Brain Development", http://mentalhealth.about. com/cs/familyresources/a/videojap.htm). This authority is concerned, moreover, that children who play an excessive amount of video games run the risk of underdeveloped front lobes and a proclivity towards violence.

At the other end of the reactive spectrum are media evangelists who see digital media as ushering in a new utopian era; the millennial generation, or 'digital natives', have an alleged inherent facility for digital tools and will function as technology's spirit guides in this new realm for us. In his 1999 book *Growing up Digital*, Donald Tapscott rhapsodizes about the "Net Generation" and its members' natural proclivity for teamwork: "Digital kids are learning precisely the social skills which will be required for effective interaction in the digital economy. They are learning about peer relationships, about teamwork, about being critical, about friendships across geographies, about standing up for what they think, and how to effectively communicate their ideas" (Tapscott, 1999, p. 107). Others tout the benefits of collaborative intelligences and distributed cognition in a networked world, practices where the best ideas will emerge from the contributions of many, and where the shared mind of the group is a computer (Rheingold, 2003; Sureicko, 2007).

The majority of published opinion, however, faults the NDM and popular culture for an array of physical and societal ills. Video games with violent or mature themes, in particular, have come under fire and extend preexisting concerns as to the effects of exposure to violent content by way of earlier forms of media (television, music). There are over 800 scholarly articles listed in the JSTOR database that deal with video games and violence, breaking down into subsets relating to race, gender, poverty, and marketing. Prolonged engagement with videogames has been linked to increases in childhood obesity, individual and societal aggression, the curtailment of more innocent forms of ritualized aggression between children, and antisocial behavior.

While an earlier generation's concerns regarding media effects may seem quaint in retrospect, the reformers were correct in recognizing that new technologies are often associated with new behaviors. As Marshall McLuhan famously declared, "the medium is the message," not the content per se. As we examine cognitive development and the new digital media, we keep McLuhan's edict in mind. While media content certainly shapes cognition, we steer clear of content analysis and focus here on how different content interacts with different media and how the potent combination influences how we think. NDM are not merely conveyers of cultural symbols, they are also symbols themselves — and objects of cognition.

Conversely, while new behaviors result from new technologies in our lives, it is critical to avoid the essentialist argument that technology wholly determines who we are and what we do. Throughout modern history, new tools and technologies have been widely introduced only to meet a variety of possible fates: failing and finally end up ultimately forgotten; being used successfully but in a manner the creators never intended; reemerging at a later date, succeeding and then fail shortly thereafter; or providing the basis for another technological advance (which may or may not succeed). We engage with media in complicated and nuanced ways; rather than passively adopt the newest technological gadget, our use is such that good technologies often fail and inferior ones succeed, and seemingly outstanding technologies are sometimes never widely introduced or accepted.

In the subsequent sections, we look closely at how young people are engaging with new digital media, and how these behaviors may or may not be impacting general cognition.

SECTION II

YOUTH NDM BEHAVIORS IN AND (MOSTLY) OUT OF SCHOOL

In this chapter, we draw on data from researchers with a particular focus on media research and cognitive development and from independent organizations such as the Kaiser Family Foundation and the Pew Internet and American Life research group. By looking closely at current NDM practices among young people, we can assess how these behaviors may be impacting cognitive development.

Preliminary findings based on this data suggest that while young people are using NDM materials in classroom and afterschool settings, they are increasingly using different types of NDM outside of the classroom and engaging with them in very different ways. This chapter addresses which NDM materials children are engaging with in and out of formal educational environments, and the growing tension between these two spheres of media use.

We start by examining the unique characteristics of NDM, such as the power of network access, the ease of acquiring material and the ability for information to migrate easily across different devices. Second, we examine school-based applications of NDM and then contrast school-based NDM practices to elective NDM practices by young people. Much of the dynamism around digital media comes from their growing ubiquity in young people's social and recreational pursuits outside of school and home. Any mentoring or assistance in these unregulated spaces happens by luck or by accident, and often doesn't happen at all. Young people challenge existing social hierarchies through their proactive, recreational uses of NDM much as their nineteenth century predecessors did by reading their illicit comic books and dime novels.

The New Digital Media (NDM) — Overview

NDM definition

For the purposes of our research, the term "new digital media" or NDM encompasses both content/software (web pages, video games, podcasts, etc.) and format/hardware (networked computer, MP3 player, mobile phone, etc.) which, combined, function as the interface between the user and the content. Given the fact that hardware and software are interdependent — one cannot function without the other — the use of 'media' throughout the paper implies a synergistic union of the two; however, as we

examine new digital media in more depth, we will at times draw a distinction between NDM form and NDM content.

NDM characteristics — Hardware

The standard NDM hardware interface is individual by design, with a computer, keyboard and mouse, an MP3 player, a cellphone, or other media appliance all designed to accommodate a single individual manning the controls. Digital devices are frequently designed to travel with the user. Few children own their own laptop computer, but most students have at least some level of dedicated and personalizable access through a school computer lab, an afterschool program, the public library, or the family computer at home or at a friend's house. This hardware is becoming increasingly mobile, with new, smaller iterations that fit in one's pocket and enable users to send text, surf the internet, play games, download music and call one's friends. NDM hardware such as cameras, photo scanners and digital audio recorders enable the conversion of non-digital source material into digital form, albeit with some loss in quality.

NDM characteristics — Software

NDM software allows users to utilize and modify existing digital materials. Various software enable users to alter or combine two or more digital files to create original work, collages and animation from visual images, sound or text files. Standard technical formats for audio or visual files compress the original non-digital form, resulting in a loss of quality which may or may not be noticeable, but which is not recoverable once it is lost (Selvin, 2007).

NDM characteristics — The Internet

The net's overall organization, or lack thereof, flows directly from its hierarchy-less, decentralized structure, which some say is a fitting parallel for postmodernism (Jameson, 1992; Turkle, 1995). Perhaps the most dynamic element of the NDM is how individual users connect with each other, primarily through the internet. The eye-popping breadth of information contained on the internet — news, games, multimedia, research — is limited only by technical constraints and seems to users to be not limited at all. The most salient characteristics of the internet are its networked communities, the extent to which its form and content are constructed by professionals and hobbyists/amateurs, the ease of accessing and distributing material online, its inherent instability, and its unregulated nature.

Mainstream educational learning with NDM

Cognition, pedagogy and NDM

Discourses on the cognitive effects of NDM chronicle a split over an emphasis on an internally driven, linear developmental model of learning as drawn by Piaget's constructivist pedagogy, and on the importance of a tutor/mentor in facilitating the learning process as described by Vygotsky, Bruner and others. In other words, what role do educators truly play in education? Setting the stage for self-directed learning, or actively guiding the learning process? Piaget and constructivists such as MIT's Seymour Papert and Mitchell Resnick suggest that children are natural learners. Given adequate time for exploration, they will manage to puzzle out how to operate a computer game, a creative application, the internet, or anything else put in front of them. This argument challenges Vygotsky's notion of "zones of proximal development"and rebuts Bruner's assertion that learning is seriously impeded without the pedagogical scaffolding of a knowledgeable instructor (teacher, peer). Proponents of 'situated learning' such as Lave and Wenger take constructivism one step further by removing individual cognition from the equation altogether and arguing that learning is primarily a social construct enacted in a community setting (Willett, 2003).

NDM in formal educational settings

In formal educational settings of non-learning disabled learners, NDM technologies are widely-used and seemingly effective methods of effecting positive change in student achievement. A clear majority of the research conducted on the efficacy of digital media in the classroom suggests that the NDM — individualized online training, games, simulations, and collective learning activities — can be an effective teaching tool when utilized appropriately. A comprehensive 1998 meta-analysis sponsored by the Milken Foundation integrated the results of over 700 empirical research studies on educational technology's impact. The overall findings concluded that students with access to computer-based tutoring, simulations, networks, and programs that provided design and programming training and students with opportunities to utilize the computer to learn higher-order thinking demonstrated positive gains on achievement tests. The study clarifies that technology in and of itself is not enough: learning technology needs to be implemented thoughtfully and consistently (Schacter, 1999). These findings suggest that, given the proper tools and adequate supervision, NDM tools can positively influence the learning experience. Parents are enthusiastic about the educational possibilities of computers, with 72% stating that the computer 'mostly helps' in the learning process (Rideout, 2003), and are likely to support schools' efforts to integrate NDM

into the classroom.

Computers have been successfully used in the classroom to facilitate writing skills. Computer-based tools used in an educational setting can range from memorization aids and vocabulary drills to creative exercises in production (programming, drawing, writing) and educational games executed on palm sized handheld machines designed to be used 'in the field' to augment situated learning practices. The latter are progressive curricula that exploit the internet as a site for exploration, learning and discovery, but there is scant evidence that educators or administrators have adopted many of these more progressive strategies. Some traditional elements of play and storytelling are being appropriated into classroom and afterschool settings and adapted for computer-based expressions. "Digital storytelling", for example, encourages children to employ digital tools to create a personal or community-based biography and is a popular pedagogical tool used by after school programs as way to teach computer literacy while engaging participants in the expression of a personal narrative.

Despite some progress, most educational software designed for classroom use simply transfer existing classroom strategies onto a computer platform in the form of a game or other activity. While many innovative public school programs creatively capitalize on the unique pedagogical affordances of the NDM, the limited pace of systemic change, a lack of funds to finance new, expensive materials or technical support, and the uncertain impact of NDM on learning contribute to cautious adoption strategies in the majority of school systems. As David Buckingham puts it, "The classrooms of today would be easily recognizable to the pioneers of public education of the mid-nineteenth century...indeed, [it has been suggested that] schooling is now heading determinedly backwards, retreating from the uncertainty of contemporary social change towards the apparently comforting stability of a new 'educational fundamentalism', in which traditional relationships of authority between adults and children can be restored" (Buckingham, 2003, p. 7). The hesitancy or inability of many school systems to undergo radical shifts in pedagogy is understandable. As a result, however, the cognitive gap between what students learn inside and outside of school continues to widen.

Researchers have been investigating how best to integrate the computer into the classroom for decades, with mixed results. In the late 1960s, MIT Media Lab researchers Seymour Papert, Daniel Bobrow and Wally Feurzeig developed the LOGO programming language, which enabled young learners to code and debug the motion of a mechanical "turtle" using modified Lisp computer code. By learning to program a 'toy', students were learning how to write simple computer commands, but also how to think creatively, plan and test a design, and assess and reflect upon their work.

At its inception, the computer-based, child-driven LOGO pedagogy stood in sharp contrast with mainstream computer learning strategies of repetition, memorization and assessment through grading. As Papert wrote in his breakthrough 1980 publication *Mindstorms*, "In most contemporary educational situations where children come into contact with computers, the computer is used to put children through their paces, to provide exercises of an appropriate level of difficulty, to provide feedback, and to dispense information. The computer programming the child. In the LOGO environment, the relationship is reversed: the child, even at preschool ages, is in control; the child programs the computer. And in teaching the computer how to think, children embark on an exploration of how they think themselves" (Papert 1980, p. 19).

Papert was articulating the parameters of a significant paradigm shift in how we think about computers and in how children might engage with these tools. The new digital media have harnessed the power of the computer and domesticated it; fast, attractive, cheap and accessible, the NDM and the internet seem made for youth engagement. While schools struggle to adapt to changing technological and cultural landscapes, young people are spending a significant amount of time engaging with new devices and new software. What are children doing with NDM when they are not in school?

We address this question of children's engagement with NDM outside of formal school-based learning in the balance of this chapter.

Unnetworked practices

It is important to be mindful that children may participate in digital activities offline or online. Most NDM activities offline mimic existing tools, rules and procedures: a digital paintbrush is used much in the same way a traditional mohair paintbrush is used, a digital version of Monopoly adheres to the same rules as its classic forbearer. To be sure, there are important differences — you can't "erase" real paint on paper, for instance, and you can't throw the game board out of frustration in digital Monopoly. But the more meaningful changes in children's cognitive development are associated with digital activities which were designed for digital play or use, and not adaptations of existing platforms.

Unnetworked video games

We now turn our attention to a favorite pastime of children today: video games. Unnetworked games occupy a liminal space between television and networked games. While they require more attention than television watching, unnetworked video games are often played on a television screen, often alone. Pew distinguishes between the different types of digital games in its 2003 study "Let the Games Begin: Gaming Technology and Entertainment among College students". The term 'gaming' includes many types of games that vary according to content, platform, and type of interaction. A significant number of online gamers are playing online versions of offline games such as solitaire and Sudoko, with little appreciable difference between the two forms in terms of gameplay or the normative solitary nature of puzzle-solving. We address non-networked games here, and online games in the section that addresses online phenomena.

Video gameplay can start early in a child's life. 30% of children aged 0-6 have played either a desktop- or handheld-based video game. These data suggest that young children alternate episodes of gameplay with no engagement. 16% of four to six year olds play, averaging a little over an hour of gameplay per day. Most of this increase in play comes from boys: in a typical day, 1 in 4 boys age 4-6 play a video game (versus 8% for girls the same age) and about 10% of boys age 4-6 play a video game every day (versus 2% of girls) (Rideout, 2003). The tween and teen population rate of gameplaying increases as online games are added to the repertoire; college students reported that they first started engaging with online games (43%) and computer games (49%) when they were in junior high school (Jones, 2003). By the time they reach college age, fully 70% report playing a video game, computer game or online game periodically, with 65% reporting regular play. By this age, the dramatic gender gap observed in the youngest cohort has narrowed: a majority (60%) of women report playing computer-based and online games, while an equal number of men and women play video games that require a special gaming console.

As for what they're playing, as of July 2007, the most popular offline video games with American college students were, in descending order of popularity, Super Smash Brothers, Guitar Hero, and Dance Dance Revolution ("16 Most Popular Video Games on College Campuses," http://www.collegeandfinance.com/16-most-popular-video-games-on-college-campuses/). Guitar Hero and Dance Dance Revolution involve performance and interesting interpretations of offline creativity—respectively, the ability to nimbly play

air guitar and perform intricate dance steps quickly. The involvement of the whole body make these games different from most previous videogames, which focused on thumb and hand dexterity. Super Smash Brothers, which assembles a cavalcade of past Nintendo video game protagonists (such as the non violent plumber Super Mario and cute yellow Japanese creature Pikachu) for an all-star Fight Club reprise. All three games are popular with both men and women. For their younger cohort, the most popular video games as of July 2007 (as rated by the NPD group) were Mario and Pokeman games played on the Nintendo Wii platform and Guitar Hero 2 and Forza Motorsport 2 for Xbox 360.

In light of this seeming deluge of gameplaying, it is important to contextualize the information. There is a spectrum of engagement on gameplaying, ranging from casual engagement to devotion. In particular, the vast majority of mobile phone games have no sustained story arc and are designed to be played quickly in the few minutes before the next phone call or the bus' arrival. Gameplaying is also not the exclusive province of the young: more women 18 years old or older play games (31%) than do boys 17 years old or younger (20%) (ETA, 2007, p. 5). At this point, video games have been around for a generation, and it appears that as children become adults, some of them continue to play video games and share the pastime with their children — parents are present 91% of the time when games are purchased or rented, and 86% of game purchases by children receive parental approval. 93% of parents who are gamers have children who also play. All data suggest that there are high-activity pockets of gaming and gamers, and that the associated cognitive affects will both be distributed throughout the general population and concentrated generationally within families.

Networked Engagement

In this section, we examine different networked NDM forms and synthesize significant findings. Given the relatively new practices of participatory culture (where participants can communicate, create, play, collaborate and otherwise actively engage online), it is not surprising that the data currently available on this front are limited, and that what data there are may be compromised by methodological problems. By highlighting both what is known and what is not yet known about cognitive development and how it influences — or is influenced by — digital media, we hope to sketch out a preliminary road map for exploring this new, uncharted terrain and to identify promising avenues for future investigations.

Battro sees the web of today as a useful motivator for learning and as a way to connect brain-injured children like Nico in pragmatic, real-world environments. He also envisions the web of tomorrow as

constituting half of a dual nervous system network, potentially complementing and augmenting the capabilities of the individual brain with a extended 'connected family' of users (Battro 2000, p. 58). The 'connected family', however, can seem less familial and at times more like a brothel or a barroom. A fundamental concern about the internet today is that it is really easy to end up in an inappropriate place online while engaged in seemingly innocuous activities such as searching for, say, images of a dog. As one commentator put it, "the Web is not a playground. Without proper supervision, children—and that's anyone under 18—are going to see and hear things that they probably shouldn't be. And before parents get all hyper about little Jonny seeing another *Brokeback Mountain* knockoff, maybe they should remember that they were the ones who let little Jonny get on the Web in the first place. The Web is not a babysitter, it's not a friendly place full of rocking chairs and whittling, but with the right parenting and sensible precautions children and teens can use the Web safely" ("MySpace Deemed Harmful to Children...Well, Duh", http://websearch.about.com/b/a/217893.htm).

Community Participation

We alluded to investigations describing the cognitive impact of screen-based computer media used for games or other training activities, as well as those evaluating the effectiveness of formalized, school-based NDM practices explicitly designed to meet pedagogical criteria. But what about the rest of a young person's time spent with NDM? Young people are no longer simply game players or media consumers: they are media producers as well. And thanks to reliable and easy access to the internet (at least for middle-class children), they are now able to share their work with the world, uploading materials to the web or even creating the websites and code needed to facilitate sharing with an indeterminate audience comprised of both strangers and friends around the world. They create these materials both alone and in concert with others, in real-time and asynchronously.

And children and young adults are not simply sharing the fruits of their creative efforts, they are sharing themselves — their taste preferences, social affiliations, even their real-time location and what they're doing at the moment. Participation in NDM-facilitated social networking practices on Facebook, for instance, has been a necessity for most college-bound and college students (Kaufman, 2007), while MySpace remains the most popular social networking site for both youths and adults (Li, 2007). And the new application Twitter allows users to broadcast, in 140 characters or less, pithy updates in real time to networked websites, cellphones, and PDAs.

These more proactive and creative practices taking place online extend Papert's conception of children as

not only telling the machine what to do, but also filling it with personal, expressive, and emotionally charged artifacts. Jenkins et al. (2006) have described these practices as belonging to a 'participatory' culture where anyone, regardless of skill level, is welcome to contribute to a variety of expressive and community-based practices, or even to start their own. Participatory culture manifests in a multitude of media forms and includes digitally-generated sounds, images, animations, videos and online games as well as text-based fiction and nonfiction work, blog posts, and conversational exchanges on social networking sites. In essence, participation is positioned as the opposite of more passive types of media engagement such as watching TV or other manifestations of mass media.

We separate online participation into three broad and often overlapping categories of progressively more community-oriented production — creative expression, social networking/gaming, and collective intelligence. It is important to keep in mind the hybridic nature of these tools as we proceed into a more detailed analysis; while we may characterize a site as one for creative sharing or social networking, there are very few 'pure' sites and most combine elements of play, community, and creativity. A web site such as Flickr is ostensibly for uploading one's personal photos. However, site users can link to other users (elements of networking), post images of breaking news stories (photojournalism), annotate their pictures with textual commentary and links (elements of blogging), comment on others' pictures (ditto). The practices surrounding these three categories of production are similar, but the questions they prompt diverge. There are important questions regarding culture and social behavior that arise when looking at communities of practice but, in keeping with the mission of this paper, we do not focus on collective practices here.

Online communities — creative expression

The web allows users with the proper connection and equipment to not only chat and play games, but also to easily share files with others, either by email or by uploading files to an internet server. In this section, we explore the characteristics of creative productions with an emphasis on work that is shared and distributed online.

Perhaps the most compelling characteristic of the NDM is that they allow — even expect — ordinary users to help construct online communities, discussions, and other online content. Amateur producers have been creating throughout human history, but the NDM have simplified the methods of production and distribution. In the past, non-professional engagement with media was limited to hobbyist practices such as ham radio or individual creative work. Producing and distributing media required a high level of

technical expertise, expensive equipment, and permissions from various governmental agencies, among other hurdles. Today, aspiring creators can purchase or gain access to a computer, the internet, the right software package and a still or video camera. On the verge of bankruptcy in 1995, the Macintosh operating system is enjoying resurgence thanks to its user-friendly production software included in all new computers. The standard iLife software suite includes applications for video editing (iMovie), music production and editing (GarageBand). Creators short on funds can avail themselves of the numerous free applications available online through Google and portals such as download.com, and can capture images and video with their versatile mobile phones. Sites such as Blogger.com allow a user to build a personal blog around any topic; other sites such as LiveJournal combine social networking elements with journal-like blog entries.

A majority of teens online create some kind of content for the internet, from coding and programming to original content creation. According to a 2005 Pew survey, approximately 57% of online teens (ages 12-17) have created content for the internet (Lenhart and Madden, 2005), with the most popular behaviors being sharing self-authored content and working on web pages for others. 33% share their own artwork, photos, music and videos online. Less is known about the production habits of their younger siblings.

Two popular sites for uploading and showcasing creative user-generated content are YouTube (videos) and Flickr (photography and 2d artwork). Founded in September 2005, YouTube is the site that hosts virtually everything available in short video format, ranging from goofy amateur, self-conscious teen productions to commercials, movie trailers, old driver's education filmstrips, and classic Louis Armstrong performances. Flickr, unlike YouTube, has stayed resolutely consumer-driven and offers users a forum for uploading and organizing digital images. Creators more inclined towards text expressions may start a blog, or "web log", a place to post text (and images) ranging from personal diary entries to political activism and commentary. 19% of teens have their own blog, with 25% of 15-17 girls and 15% of older boys blogging.

Online communities — social networking/gaming

Online social networking sites are becoming a critical social tool in a young person's life, whether s/he belongs to a dedicated site such as Facebook or MySpace, or a hybridic site, primarily an online game (such as the online MMORGP (massively multiplayer online role-playing game) World of Warcraft or Second Life), or a site for sharing digital creations (such as YouTube or Flickr) that also has a social component. 55% of American teens ages 12-17 are using online social networking sites; older girls tend

to use them to reinforce existing friendships, while boys tend to use them to make new friends and to flirt (Lenhart and Madden 2007, 1). According to a 2004 survey performed by Jupiter Research, 71% of teens between the age of 13 and 17 use instant-messaging programs on their computers to communicate with their peers (Ewalt, 2004).

A recent study by Forrester Research also found that 60% of teenagers (ages 12-17) and 80% of young adults (ages 18-21) use social networking sites; 60% of teen users and 67% of young adult users visit their site(s) daily. The clear favorite is MySpace: more than 50% of social networking site users visit MySpace on a daily basis. Facebook, a social networking site originally designed exclusively for college students, has relaxed its membership requirements and has retained users who would have otherwise graduated out of the site. Several other, less popular, social networking sites are also available, such as Piczo, Dubit, or Faketown.

Children are engaging in online communities at younger and younger ages. Although the official cutoff age for MySpace is 14, a 2006 LA Times/Bloomberg study found that 38% of tweens aged 12 to 14 (both boys and girls) claimed to frequent the site; given that these tweens are in violation of the site's age cutoff, it is fair to assume that the percentage of tween users is actually higher than reported. Children 12 and under are getting acclimated to the mechanics of social networking through Club Penguin, Neopets, Webkinz, Imbee, and Club Barbie. These sites often straddle on- and off-line play. The WebKinz user experience, for instance, requires one to purchase a special Webkinz-tagged plush animal from a store and then register it with the website, where an animated representation of the plush animal provides the basis for playing and socializing with other animated plush pets. At Neopets, one engages with (surprise) another pet; at Imbee, it's trading cards and music. The most popular website for tweens and their younger siblings, however, is Club Penguin, which launched in October 2005 and averages around four million unique visitors per month. Around seventy percent of its registered users are between the ages of 12 and 17; fifty-three percent are female ("Club Penguin-FAQs", http://www.clubpenguin.com/help/ frequently_asked_questions.html). Club Penguin's play consists of customizing one's penguin's appearance and attire, decorating one's igloo, and interacting with the other penguins in Penguin Village ("MySpace with Braces", http://www.msnbc.msn.com/id/17266131/site/newsweek/).

Then there are the massive multiplayer role-playing sites such as Second Life (SL) and World of Warcraft (WoW). "At last, the world of Azeroth, first glimpsed in the original Warcraft: Orcs and Humans, is brought to life in glorious detail," reads the WoW site's introduction. "...As a massively multiplayer online game, World of Warcraft (WoW) enables thousands of players from across the globe to come

together online—undertaking grand quests and heroic exploits in a land of fantastic adventure" ("World of Warcraft—Introduction", http://www.worldofwarcraft.com/info/basics/guide.html). WoW is a deeply complex alternate online universe where teams or 'guilds', tightly structured social hierarchies, work together towards completing various quests. There are also hordes, alliances, and questing parties, different social groupings with different functions. SL, unlike WoW, distinguishes between children under 18 and adults, and has a special online 'island' where minors are welcome. Rather than joining a guild or questing party, SL players can go to the disco, a book signing, a concert — many of the social activities people can do offline, as well. Which raises the following question: why do people engage in activities online or in games which parallel real-life behaviors?

Some argue that current social networking practices differ little from earlier teen practices of chatting on the phone for hours (Henning, 2007) or playing freely outside. It should be noted that the behaviors associated with these two different connective technologies, while similar in some ways, are different in others. The ability to conduct multiple simultaneous conversations, for instance, is new: before NDM social networking capabilities, conversations with more than two participants needed to be conducted in person, or a single conversation could be conducted remotely via the telephone.

Online communities — collective intelligence

NDM not only allow for individual creative expression; they also facilitate collaborations among individuals and groups that would have been difficult or impossible to implement before digital media. In his 2000 book, *Collective Intelligence: Man's Emerging World in Cyberspace*, media scholar Pierre Levy frames collective intelligence as like-minded individuals gathering online to embrace common enterprises, which often involve access and processing information (Levy, 2000).

Although this practice is relatively common in professional circles, we have not been able to find any data which describes in detail the extent to which young people are engaging in collective intelligence practices online. From fans of the television series *Lost* and participants in the alternate reality game "I Love Bees" to citizen journalists and New Orleans residents sharing information on Hurricane Katrina, ad hoc collectives organize online to debug code, play games, write papers, compose music and report news. Perhaps the most well-known instantiation of collective intelligence is Wikipedia (http://www.wikipedia.org), an online encyclopedia where entries can be written by anyone with a registered account. Wikipedia relies on a small group of editors and the contributions of many

independent volunteer writers, many of them teenagers, from around the world to refine over two million articles and to submit new ones.

Mobility and NDM

Not only are children using more NDM outside of the classroom and the observant eye of an educator; they are now able to use it outside of the home and the watchful eyes of the parents. Imagine the possibilities for a curious child, both good and bad, as technologies become ever more portable, and children are granted access to NDM unsupervised and unmentored. In musing about Nico, the young boy who had the right side of his brain removed, Battro says that, "...a portable computer is the perfect tool for students of all ages... for Nico it was not only an innovation but the perfect companion and more than that, the computer became his 'information prosthesis', to use Seymour Papert's phrase" (Battro, 2000, p. 64). Size matters, and digital tools are shrinking in size and cost such that sophisticated tools can now fit in the palm of your hand. Storage drives, phones, cameras and other hardware of the digital life are becoming smaller and more portable every year.

Overwhelmingly, the cellphone is the device that youth own and cherish as both a practical communications device and as a way to tend to the cultivation of those social networks that play a large role in constructing one's identity. It is increasingly difficult to monitor internet usage when the web is accessible from a teen's cellphone—the cellphone her parents bought her so that they could stay in better contact. According to a 2005 Pew study, 45% of American teens own their own cellphone, with 33% of teens having a cellphone that can send a text message (Lenhart et al., 2005, ii). The right cellphone could eliminate one's need for other devices: select models can play MP3s, access the internet, send text messages, play games, snap high-quality photographs, and even upload digital materials to a website. In 2005, 68% of the 13-25 cohort had sent and received text messages through their phones, and close to 50% had used their phones to take a snapshot and share it with others ("M:Metrics first montly benchmark report", http://www.mmetrics.com). Internet gaming, in particular, is experiencing strong growth on the cellphone platform. 51% of frequent game players say they play games online, up from 19% in 2000, with online gamers fairly evenly split between males (53%) and females (47%). The games most played online are 'puzzle/board/trivia card games' such as Sudoko or online solitaire.

However, despite the miniaturization of devices, most 12-17 year olds are still accessing the internet from desktop computers either at a public library, at an afterschool space, or at home. Of those who access the internet at home, 73% use a computer in an 'open family area' (Lenhardt et al, 2005, v). At this point in

time, cellphones are primarily used as phones and as a texting portal, with limited internet use. However, given the strides in mobile technologies in recent years, it is likely that as the wifi network grows and devices become more powerful, this behavior will change. The target market for cellphones may be changing as well, with more tweens and younger teens using cellphones ("Cellphone marketers calling all preteens", http://www.usatoday.com/tech/products/gear/2005-09-05-preteen-cell-phones_x.htm).

So, children are engaging in a wide variety of NDM practices ranging from video games to social networking applications and creative endeavors. They're using NDM in school, at home and — for those with the right hardware — anywhere they'd like to use it. Given the ubiquity of NDM in young people's lives, it is difficult for researchers to accurately assess patterns of use. It is fair to say, however, that sustained levels computer and cellphone engagement are shaping the habits of mind of young people. In the following chapter, we present both proven and possible ramifications of NDM use.

SECTION III

NDM SKILLS AND COGNITIVE DEVELOPMENT

Viewed collectively, certain commonalities begin to emerge across observed NDM behaviors. The average NDM user, for instance, repeatedly engages with a screen of some sort, a keyboard, a mouse or other operational buttons. She must deal with a potential avalanche of information, constantly make choices both large and small, process information visually, textually, and/or orally, and deal with multiple and simultaneous demands for her attention. These behaviors are strongly influenced by the user's developmental capacities as well as by a variety of external factors, including the frequency and type of engagement and the level of supervision for the tasks.

In this section, we identify broader shifts in the interplay between cognitive development and new digital media and outline practices which appear to impact cognition. We ask two questions of each behavior presented: What demands might this behavior have on a child? And what habits of mind does consistently practicing this behavior instill in a child? These questions reveal the hidden demands of each task—demands which might cause children to struggle more than adults do—as well as the potential developmental repercussions of "growing up digital."

Word processing and typing

Word processing is one of the oldest and most common uses of computers among users of different ages. A recent marketing survey found that 66% of children who had computers at home used them to complete homework assignments, with 88% of those children reporting usage of word processing software to complete school reports (Pastore 1999, p. 1). We must also note the primacy of typing as input mechanism for many different media, well beyond word processing. Typing is the primary mechanism for entering search strings, URLs, blog entries, instant messages, and emails, not to mention typing phone numbers and text messages on a cell phone's tiny interface.

Very young children will often be hindered from becoming proficient typists by their motor skills, but most children are capable of learning to type by age ten or so. Those who do not learn how to touch-type at a young age are likely to be at an academic disadvantage as they grow older and are expected to complete typed assignments.

Word processing software is notable because it typically lessens the demands of pen-and-paper writing. Pen-and-paper writing usually requires more explicit pre-planning because on-the-fly editing is difficult or impossible. Ask any adult who attended university in the days of typewriter, and s/he'll tell you that having a perfectly polished long-hand draft before starting to type was essential, as were precise typewriting skills—and facility with a jar of White-Out, correction tape or small erasers. Word processing software allows a user to edit as s/he types, spontaneously editing and rearranging texts with the copy and paste function. It is also more forgiving of motor dexterity and spelling difficulties. Typically, even those with very poor handwriting can become proficient typists, and most common misspellings are immediately recognized by an embedded application.

It is currently not clear how children learn how to type. Editing text produced on a typewriter was possible, if not easy; the process of typing a document often followed a separate act of composing the document. The moneyed classes relegated their typing responsibilities to the service or support classes, who took classes in stenography and typing. A word processing program allows the writer to compose and type his text simultaneously; typing is no longer a separate step. A young child engaging with NMD may be using portions of a keyboard for game playing or digital painting before s/he is textually literate; as the child matures, s/he may graduate from a primitive hunt and peck approach to a more fluent hunt and peck approach or to touch typing. It is not clear whether typing is still widely taught as part of the high school curriculum.

Studies have shown that the use of word processors can be beneficial for children learning to become better writers. In a meta-analysis conducted in 2007, word processing technology was found to have an overall moderate effect on student writing quality, with a moderate-to-strong effect on students whose writing quality was originally poor. The authors conclude that "word processing appears to be an effective instructional support for students in grades 4 to 12 and may be especially effective in enhancing the quality of text produced by low-achieving writers" (Graham and Perrin, 2007).

Word processing instills habits of mind around instant editing. While writers of the past may also have thought non-linearly, the inconvenience of scratching out, drawing arrows, or starting afresh may have encouraged them to structure their thoughts as linearly as possible before setting pen to page. Current writers may be more likely to type as they think, creating a jumble of sentences that can then be played with onscreen. Word-processor users have the expectation of "I can fix it later," which often means higher quality drafts because extensive editing is facilitated. However, the flip side is that, while the technology

facilitates easy editing, children may simply not do it, and instead pass in the equivalent of a sheet of scratch paper that, thanks to nice fonts and laser printers, looks appropriate (Graham and Perrin, 2007).

The ease with which one can copy and paste directly from the Web also makes plagiarism much easier. Nonetheless, since word processing is an older technology, the long term impact of growing up on word-processors is already felt by today's generation of young adults, many of whom can literally not imagine writing an academic paper long-hand. Germane to the issue as well are online calculators and related tools, which handle an array of tasks for the computer user. We explore some of the possible implications of these tools in the subsequent section "NDM as toolbox".

Screen time

Interfacing with digital media can feel entirely disembodied, as if the mind is directly connecting to information. But that sensation is largely an illusion. Even with the most advanced interfaces developed for the physically disabled, interfacing with digital information still requires some kind of motion from an embodied self. For most users, this means using one's hands on computer keyboards and mice or on cell phone touch screens. It also means focusing one's eyes on a screen for extended periods of time, usually sitting stationary in a chair.

We've already mentioned that interfacing with many types of digital media demands typing and that very young children often lack the motor coordination to become proficient typists. In addition, very young children's eyesight might not be adequate for viewing many NDM screens (Baumgarten, 2003). However, companies like My Little Genius produce child-sized keyboards and mice to facilitate a child's ability to manipulate standard computer interface tools, and virtually all computer monitor can be placed on "bigger font" setting for users with poor vision.

But switching from navigating a real-world social environment to navigating a virtual social environment increases the cognitive demands on participants in abstract ways that younger children may not yet be equipped to handle. In virtual space, users no longer have access to social cues that we have relied on for millennia—smiles, laughter, eye contact, and body language. Users must attempt to interpret often-complex social meanings in text, a medium not well suited for it.

Cognitive researcher Jane Healy suggests that younger children's experience on a computer is reductive

(limiting learning to visual/oral sensory input), dependends on flashy visuals and special effects, and takes valuable time away from real-world learning experiences (Healy, 2004). A 2004 paper by Garland and Noyes provides evidence that learning via screen reading takes longer than its paper-based counterpart, and suggests that the subtle fluctuations of the monitor's light levels may be to blame.

More research on how children interpret online messages—under what circumstances are the messages received as intended, what increases or decreases ambiguity, and how young children differ from older children and adults—will be vital to understanding how children navigate this complex new social milieu.

Video Games

Much of the psychological research on game playing examines gaming's impact on an individual's visual cognition and mechanical skills. The results are generally unsurprising — game play affects like other reward-seeking behaviors, positively affects manual dexterity, memory and visual acuity and negatively affects sociality. The deeper cognitive implications of this type of engagement are not considered.

Since gameplay often involves the mental rotation of objects (Tetris being the quintessential example) and the navigation of complex virtual environments, cognitive scientists have been eager to see if experience with games changes the players' minds. Research has revealed that when compared to non-gamers, frequent gamers have higher visual acuity, enhanced visuospatial attention, and increased serial processing speed (Green and Bavelier, 2007, 2006, 2006b). In general, regular players of games with a strong spatial component do better on subsequent tests of spatial abilities (Subrahmanyam, Greenfield, Kraut, and Gross, 2001). Although these attainments do not universally generalize to all spatial abilities, players do get better at the specific task practiced in the game. What's more, research suggests that video games change the brain as well, at least while the user is playing them. Videogame players experience bursts of dopamine in areas of the brain associated with reward-seeking behavior (Koepp, 1998) and experience patterns of blood flow to parts of the brain that control motor functions and executive planning (Nagamitsu, Nagano, Namashita, Takashima, Matsiushi, 2006). However, it is important to bear in mind that these results reflect changes in the abilities of self-identified gamers and do not necessarily reflect the cognitive effects of gaming on the general population.

In a 2001 article, Subrahmanyam, Greenfield, Kraut, and Gross assert that the cognitive skills children gain through game-playing will benefit them later in life: "the suite of skills children develop by playing

such games can provide them with the training wheels for computer literacy and can help prepare them for science and technology, where more and more activity depends on manipulating images on a screen" (p. 13). Game-players' enhanced visuospatial skills, facility with iconic representations like maps and diagrams, and ability to divide their attention across multiple areas of gameplay, they claim, are necessary skills for many of the technology jobs of the future. In a separate article, John Seeley Brown (2006) expands the benefits of gameplay beyond pattern recognition to include cognitive skills such as sense-making and decision-making in confusing environments, multitasking, pushing limits, exploration, and the ability to not get discouraged and learn from failure. Media researchers Patricia Deubel and Marc Prensky both tout the advantages of harnessing the pedagogical power of game play and cite potential benefits such as expanded vocabularies, improved memory skills, customizable learning levels, enhanced planning and problem-solving skills, embodied cognition, and student engagement as potential benefits of a well-designed game experience (Deubel, 2006). How these skills might transfer from a game to a professional or academic environment, however, is still undetermined.

Finding NDM material

Much of the internet requires users to make choices: which sites to visit, which links to click, which materials to exchange, and which information to trust. There is an abundance of information, and each choice a user makes can drive him or her further from or closer to stated goals. Search and surfing, covered below, are important means of finding sources of information online—but finding a source is only the beginning. Users must assess a variety of options among searching options, select one, and then assess the validity of the found information or the safety of the options presented to them (such as entering a credit card number). Children must make the same series of decisions as adults, but with less experience and different cognitive skills at their disposal.

One of the fundamental characteristics of the internet is its organization, or lack thereof. Originally a limited, closed system used within a few trusted communities, the internet is now accessible to anyone with a computer, a browser and a network link. Due to the system's decentralized construction, no one knows what, exactly, is on the internet at any given time, the total number of web pages, or the amount of storage space devoted to maintaining the system. Instead, individual servers link computers to a shared pool of information. On this online data superhighway, there are few roadmaps to help a user find what s/he is looking for. Whether using a computerized library database, an iPod music library, a file-sharing server, or the Internet, the need to search online is ubiquitous.

Search

Search is a general term for an often complex skill. Search begins with selecting an appropriate search strategy: selecting a search engine, browsing a directory, or surfing to a known site. This kind of strategic thinking develops slowly across childhood. Studies have shown that, in general, older children or adults do better than younger children in all search-related tasks (Bilal and Kirby, 2002; Freedman, 2003; Schacter, Chung, and Dorrr, 1998). Most studies have focused on the role of experience, instead of cognitive development, in selecting an appropriate search strategy. Experience with search technology has been found to affect search precision (Park and Black, 2007), positive attitudes towards search usage (Liaw and Huang, 2006), and optimal strategy selection (Aideen, Rogers, and Fisk, 2006). Since children often have less experience with search technology, their strategy choice is often sub-optimal. Compound this with poorer strategic thinking in general (Rose and Meyer, 2002), and children face challenges before information seeking has even begun.

Let's explore search behavior using an example of a child interested in learning more about baby alligators. Common search strategies for children are to visit a familiar (if less relevant) site, such as www.nationalgeographic.com, or type their search term between www and com, thus creating a structurally correct if misleading URL like www.alligator.com (Guinee, Eagleton, and Hall, 2003).

 If our child does not find relevant information using the above two strategies—indeed, www.alligator.com is a site for a record-label—he may, by luck or instruction, find his way to a search engine. But he must then enter an appropriate search string, tapping into his verbal ability. The child must know the appropriate word to search for, and (more frequently in the past but less so as search technology improves) how to spell it. The child must be able to think of synonyms and similar terms if the initial strategy fails—alligator babies? Infants? Young? Hatchlings?—tapping into webs of linguistic associations that may not be as developed as an adult's. Where children lack domain knowledge or struggle with the reading level of the material, research suggests their search may be less precise or fail entirely (Park and Black, 2007; Smith, 2007). Moreover, children must be familiar with the discourse of the field they are investigating (Gee, 2001). If they are interested in scientific information only, they are likely to be overwhelmed with irrelevant material unless they can add cues appropriate to the field sought.

Selection of an appropriate search string can be influenced by the child's understanding of how the internet works. For example, children in several studies tended to use natural language that caused sub-optimal search results. In our example, our child might enter "what do baby alligators look like," while

something like "alligator hatchling appearance" might result in more precise results. Guinee, Eagleton, and Hall (2003) note that this may be because "[children] retain the paradigms that work in the physical world. When asking librarians or teachers for help, students customarily use phrases and questions and repeat concepts for the listener" (ibid, p. 372). Instead of repeating the language of the real world, children need to switch to a "computer world schema," based on the literal logic of search engines (p. 373). However, whether children fail to understand the technical complexity of the Internet due to lack of experience, lack of direct instruction, or lack of developmental competence is unknown.

As the child begins to explore the results of their search, memory and attention resources are put to the test. Developing attentional control mechanisms may make it harder for the child to stay on task or not be distracted by, say, flashing advertising. Past research has suggested that children do struggle with attention span issues, clicking between pages before they have had time to read them and making judgments based on surface structures such as graphics (Guinee, 2004).

A key caveat must be made regarding research into children's search behavior. Researchers tend to phrase their findings in generalized terms about children's capacities, but we must remember that research on human-computer interaction tells us as much about the computer as about the human. For example, a frequently-cited 1998 study claimed that "children are interactive searchers who engage in little planning when approaching information-seeking tasks. Their search strategy of choice on the Web is browsing, which constitutes over 80% of their total information-seeking behavior" (Schacter, Chung, and Dorr, 1998, p. 848). It's easy to take this as a blanket description of what all children are like today; but context is absolutely essential. The study was done in 1996 with 5th and 6th graders in California who used Netscape Navigator—a then-popular browser which now captures less than 1% of the market share—and the Infoseek search engine—which is long out of business. The preference for browsing over search that the children in this study showed may merely be a reflection of the poor search technology available at the time. If so, adults would share this preference, but no such comparison group was studied. Research can be greatly strengthened by comparing adult and child search behavior using the same technology.

Surfing

"Surfing" the web is closely associated with, though distinct from, searching the web. Both practices provide the user with additional information but searching is more deliberate and surfing is more casual. Net pages are richly interlinked, so "reading" a webpage is a much less linear experience than reading a traditional text. Users can stop reading mid-paragraph to follow an outgoing link, abruptly switching

topics or even media, from text to audio or video.

The non-linearity of online text has distinct advantages and disadvantages. Hyperlinks can be a boon to instructional designers, who use them in online readers to define words, provide additional instructions, or link to background material. This capacity has led to the birth of "assistive readers" to help learning-disabled children increase their reading comprehension (Hasselbring and Bausch, 2006). Such readers guide the child in understanding the text and can provide customizable assistance based on the child's performance.

The drawbacks of non-linearity are brought into clear relief by what instructional technologist Mary McNabb calls the "myth of teen competence" (McNabb, 2006, p. 78). Influenced by concepts like the "digital native," we tend to assume that teens are as comfortable with digital texts as they are with written text if not more so. However, McNabb has observed that teens falter in hyperlinked environments, growing confused and overwhelmed by the overload of disconnected information. She cites an informal study done by usability guru Jakob Nielsen that showed that teenagers completed the online task they had set out to do only 55% of the time, compared to 66% for adults (http://www.useit.com/alertbox/ teenagers.html). Teens may actually be no more comfortable with online text than their parents; in fact, teen's frequent poor literacy strategies and faulty comprehension self-monitoring can mean that they get much less out of an online session than they would have in an hour with a textbook.

Nielsen conducted a similar informal study with younger children aged 6-12 of surfing behavior ("Kid's corner: Website usability for children"). He observed that children suffer more from usability flaws than adults; children were more likely to get lost on a site, re-click already-visited areas by mistake, click randomly and indiscriminately, click on ads without realizing they were ads, fail to scroll down a page, and simply get frustrated and leave the site.

These two studies point out the many competences that surfing through non-linear text demands of children. If children are browsing to meet a certain goal, they need to be able to make a plan regarding their purpose and how they intend to achieve it, without getting side-tracked by interesting yet irrelevant material. Even if surfing just for fun, children still must monitor their comprehension of material and choose appropriate strategies to rectify any confusion they might feel in order to avoid getting frustrated and quitting. They must understand which areas of the page are clickable and which are not, and how online tools like scroll bars and collapsible menus work. More studies are needed into how children and teens interact with websites and particularly how developing literacy intersects with online texts.

Social bookmarking services such as del.icio.us or Furl allow users to tag websites with their personal webs of associations, so that they, and others, can find them later. Built on the standard browser-based bookmarking paradigm, social bookmarking sites allow user to save a URL online (instead of on their local machine), organize URLs with multiple tags (rather than single folders), and share their favorite URLs with others.

Computer-generated searches

Web discovery services like Stumbleupon exist purely to help users find fun stuff on the Web. The Stumbleupon browser toolbar allows users to press a button which will deliver them to a random website, based on their recorded preferences and other users' recommendations. This paradigm is entirely different from search; the user isn't looking for anything other than to be entertained. It is perhaps the internet equivalent of channel surfing, with all the accompanying implications. This technology is so new that no research appears to exist on user patterns. But its existence adds an interesting wrinkle to surfing behavior. As its technology improves and its predictions become even more precisely tailored to each user, web discovery services have the potential to be extremely compelling—perhaps even addicting. An important future research agenda might be to study children's internet usage patterns during leisurely, non-directed surfing and how these patterns relate to time spent on other activities, to social and emotional development, and to literacy and content knowledge.

While children are learning the fundamentals of NDM navigation, what broader habits of mind might they be cultivating? And how do these habits differ from past practices? Here are some intriguing possibilities:

The research presented thus far gives us a snapshot of children's search behavior at a particular time and place—namely, sitting down in a laboratory setting to complete an individual search task. But many of today's children are growing up with search. What might some of the long-term effects of using search technologies over the course of a childhood be? To answer questions like this, longitudinal studies are required. We might see an enhanced or earlier manifestation of the ability to think of synonyms and alternative ways of expressing things, as well as more fluency with "computer speak," or the search strings that computers prefer (Guinee, 2004). The best searchers may be able to think of many different ways to describe the same information, and each bit of knowledge they have may be richly interconnected in a web of synonyms and mental hyper-links.

At the same time, children who grow up with the expectation of always-available search may falter when faced with settings where such search is not available, such as filing cabinets. As directories — web portals organized by subject categories progressing from general to detailed — continue to fade from prominence as they did when Google search outshined the previously-popular Yahoo directory, people may find directories increasingly confusing or alien, even in instances when such directories may be more appropriate (when there is only a small amount of data for intended for browsing, for example). Overreliance on search can also cause students to skim the surface of information. Instead of reading a complete document, they may skip from keyword to keyword and miss out on important nuances of the argument.

Finally, the web's organization might also be encouraging the collapse of the boundaries between different disciplines (Tapscott, 1999; Weinberger, 2007). Absent a hierarchical, linear structure of organization, information online is presented as a series of branching, rhizomic structures. Rather than identifying with strict categories of information like science, math, and architecture, children may more easily perceive interconnections between topics and maintain a dubious understanding that all knowledge is "interdisciplinary'.

Managing and Understanding NDM material

Once a young person manages to gain access to NDM content — an online game, a social networking site, a content sharing site — what then? How does s/he engage with this information? In Section II, we presented the NDM content that young people are accessing. Here we ask how they are engaging with it, and what habits of mind might form as a result. Much of the internet requires users to make choices: which sites to visit, which links to click, which materials to exchange, and which information to trust.

Search and surfing, covered above, are important means of finding sources of information—but finding a source is only the beginning. Users must assess an enormous array of search results, assess the validity of that information or the safety of the options presented to them (such as entering a credit card number), and try to make the best selection. Children must make the same series of decisions as adults, but with less experience and different cognitive skills at their disposal.

Judging credibility

As young people search and surf through digital media, they must determine which information to trust. Which sources are trustworthy and reliable, and which are out merely to make money or sell a product? While this is a serious issue that young people must address, training students to look for the motivation behind different media has been the one of the primary foci of media literacy education programs since the mid-1970s ("CML, Best Practices", http://www.medialit.org/best_practices.html). In the Web 2.0 world of user-generated content, determining trustworthy information online is more complicated, especially since the average web page often does not disclose who has written its content, where the information originated, or who pays to have it published. Often, sites that feature user-generated input have admirable intentions but fail to present reliable information.

Wikipedia.org may be the best-known wiki, or collaboratively-produced site for shared knowledge, on the internet. Framed as an online encyclopedia, Wikipedia's fame comes in part from its user-constructed posts on a wide range of topics that transcend the traditional definition of what an encyclopedia can be. However, much like the internet itself, Wikipedia is nominally monitored. Critics have pointed out that Wikipedia's entries are generally not written by experts, but by a range of contributors including the well-educated, the well-intentioned, hackers, proselytizers, and partisans. Fans counter by asserting that entries are written by multiple contributors who diligently correct any errors they encounter. A 2005 study conducted by the science journal *Nature* concluded that Wikipedia entries relating to science were comparable to similar citations in the Encyclopedia Brittanica; the venerable encyclopedia publisher subsequently criticized the study's research methodology ("Wikipedia study 'fatally flawed'", http://news.bbc.co.uk/1/hi/technology/4840340.stm).

Matthew Eastin carefully outlines a developmental sequence for perceptions of credibility, using a largely Piagetian stance (Eastin, 2007). He notes that to meet the demands of accurately judging credibility, children must be able to evaluate the information they've found based on past experience and knowledge about relevance and context. The ability to integrate new information with old develops as children age and gain experiences. Younger children, says Eastin, struggle with distinguishing between fantasy and reality. Other theorists note that digital media provide a particularly challenging context for children, because the distinctions between actual and virtual, real and simulated are increasingly blurred (Baumgarten, 2003; Turkle, 1986).

This blurring of boundaries may make it even more difficult for children to learn the distinction between fantasy and reality (Subrahmanyam et al, 2002). Children in Piaget's concrete operational stage (ages 7 - 11) may focus more on "superficial indicators of credibility" such as site design or flashy graphics (Eastin, 2007, p. 36) (as do many adults). Children who have successfully reached the formal operational stage (11 to adolescence or adulthood) have gained the capacity for formal logic and scientific thinking. At this stage, Eastin proposes, children are equipped to make adequate credibility judgments. However, Eastin notes, children at all ages are limited in their strategy selection, information processing ability, short-term memory capacity, as well as by the ever-increasing complexity of the media available to them.

The concept of "reflective judgment" — the progressive ability to assess an argument based on its evidence, sources, and consistency — provides a compelling framework for examining user engagement with internet content. Reflective judgment outlines progressive stages for determining the validity of an opinion, from understanding knowledge as an inflexible and immutable thing, where knowledge is either right or wrong (Stage 1) to wielding a nuanced conception of knowledge as constructed and as the product of multiple, often culturally constructed, factors (Stage 7) (King and Kitchener, 1994, pp. 14-16).

King and Kitchener's Stage 7 resonates with sites of constructed knowledge such as Wikipedia, where definitions are determined by the credibility of contributors, the volume of information and the coherence of the presented argument. Trevor Batten, a UK-based artist and digital scholar, also reiterates the importance of argumentation and process over specific online content (Batten, 2003). If one considers knowledge as nuanced and constructed, Wikipedia can be read as a harbinger of a future where shared definitions are explicitly constructed (and contested) by small groups of interested parties. While this development is inherently democratic, students of history understand that groups often do not behave in a rational manner and that this behavior is not likely to change in the near future.

In general, the sheer volume and diversity of expressed opinions on the internet require the user to move beyond understanding the different sides of a given argument to implementing higher-order reflective judgment skills as a means of assessing the credibility of each side. How collectively-generated knowledge will engage with mainstream, well-established scientific practices of knowledge collection is yet to be determined.

Users looking to judge a site need to be mindful, also, of the practices surrounding collaborative intelligence as manifested by different types of online 'polls' or ratings systems. Many online sites such as consumer portals and news outlets rely on user participation to gauge the perceived value of their

content. The theory of collaborative intelligence is based on the idea that if enough users evaluate online material, the statistical outliers will grow increasingly insignificant (Rheingold, 2003; Surowiecki, 2005), and that the final rating will authentically reflect the community's opinions. While this practice works well in certain arenas, its success depends on a number of variables, including how the system is set up, the level of participation and authority among participants, and whether it is a voluntary or commercial enterprise (Krowne and Bazaz, 2004). A study at Columbia University addresses how decision-making online is influenced by the decisions made by others. In the study, 14,000 web participants were separated into nine separate groups and given identical musical selections to rate and download. One of these groups could not see what their peers had downloaded, while the other eight groups had access to this information. Scientists observed what they coined 'cumulative advantage', or the influence of early downloaders to shape which songs subsequent participants downloaded, strongly suggesting that online participation adheres to a certain level of conformity, and thus may not accurately reflect the authentic choices of individuals (Watts, 2007).

Constant Access, Constantly Occupied

Increasingly, middle-class teens have 24/7 access to both online assets and to each other. The online game, online peer group, online library and online department store are all perceived as being constantly accessible, available and ready for engagement, unlike their offline counterparts which still have an "open" or available state and a "closed" state.

When teens aren't able to access a desktop computer to IM with friends, they use their phones (Ewalt, 2004). Given the increasingly affordability of powerful, portable devices, young people are more able to play games and to link to NDM than ever before. Developing games for portable devices is a booming business: mobile game sales have topped ring tone sales in the UK in 2007, and Asia has seen mainstream gaming titles adapted for mobile platforms ("U.K.: Mobile Game Sales Overtake Ringtones", http://biz.gamedaily.com/industry/feature/?id=16375; "Mobile Gaming toplines Tokyo Fest", http://www.hollywoodreporter.com/hr/content_display/international/news/e3i5bf6a751bdf67ff52fa8f87cc 26c2be7).

80% of teens never shut off their mobile phones, enabling them to constantly participate and manage contact with their social network (Stald, 2007, pp. 5-7). Stald tells of a typical teenage girl heading to bed with her cellphone by her side, at the ready, just in case a friend needs her. "One 19 year old girl says that even if she sometimes turns off her mobile phone when she needs to relax, it isn't for long — 'I can't be

without it for too long. What if I miss something? [laughs]'" (Stald, 2007, p. 13). Communications professor Donald Roberts notes that his students "can't go the few minutes between their 10 o'clock and 11 o'clock classes without talking on their cell phones." Digital appliances are becoming more portable, powerful and affordable, allowing more children and parents to afford such a purchase.

In an article published earlier this year in *Forbes* magazine, Sherry Turkle contemplated some of the possible repercussions of our always-on world. Turkle wondered if young people, constantly tethered to friends and parents via their cell phones, would fully develop an independent sense of self and an ability to function without a network of support. "On the one hand, cell phones for teens give teenagers new freedoms. On the other they do not have the experience of being alone and having to count on themselves; there is always a parent on speed dial. This provides comfort in a dangerous world, yet there is a price to pay in the development of autonomy…The cell phone tether buffers this moment; with the parents on tap, children think differently about themselves" (Turkle, 2007).

Separate from multitasking is a need (or desire) to constantly monitor one's incoming data across multiple platforms; media theorist Linda Stone calls this practice "continuous partial attention (CPA)". Stone suggests that this state of constant vigilance, a byproduct of a competitive, information-driven culture, generates an artificial sense of constant crisis and the need for continual vigilance. Stone suggests that in small doses, CPA can facilitate functionality. Too much, however, can compromise one's ability to reflect, to make decisions, and to think creatively. "In a 24/7, always-on world, continuous partial attention used as our dominant attention mode contributes to feeling overwhelmed, over-stimulated and to a sense of being unfulfilled. We are so accessible, we're inaccessible. The latest, greatest powerful technologies have contributed to our feeling increasingly powerless" (Stone, 2007, p. 2). Some of the major cognitive behaviors associated with mobile media use are split attention, multitasking, and the habit of constant stimulation as well as extreme social connectivity— never having to be alone or far from friends. It is easy to get immersed in these alternate worlds, which exist online, 24/7, waiting for the user to reconnect. In the 2003 Pew study on gaming, college students' most cited reason for playing games was to alleviate loneliness and boredom (Jones, 2003). "And what of adolescence as a time of self-reflection?" mused Turkle in *Forbes*. "The culture that grows up around the cell phone is a communications culture, but it is not necessarily a culture of self-reflection—which depends on having an emotion, experiencing it, sometimes electing to share it with another person, thinking about it differently over time. When interchanges are reduced to the shorthand of emoticon emotions, questions such as "Who am I?" and "Who are you?" are reformatted for the small screen and flattened out in the process" (Turkle, 2007).

The "always stay entertained" habit of mind is one of the most problematic for parents, educators, and journalists. Kids today seem to be always consuming media — watching TV, listening to music, talking on the phone, surfing the net, instant messaging, and all at once. With 24/7 access to NDM and to each other, there is always something to consume or someone to engage with.

To some, children capitalize on the NDM's ability to provide constant entertainment, stimulation, gameplay, information, and contact with social groups. Disconnecting from this power center can result in discomfort —a kind of "I can't stand the silence" (quoted in Wallis, 2006, p. 4). In the words of one author, "Never before have parents had such little influence over the lives of their children. Theirs is only a single voice in a universe of sounds, sound bytes, sights, and sensations" (Ziegler, 2007, p. 76)—a universe, in other words, of media and competition for the attention of young minds.

With access to games and online content growing via improved mobile game technology and improved opportunities for to connect to the internet wirelessly, this trend of 24/7 access shows no signs of abating in the near future. What are the possible implications of being always linked to others through cell phones and other technologies? Will it affect the development of independence, self-reliance? And if young people are spending so much time in virtual spaces and communicating with remote friends, to what extent are they able to notice and appreciate the physical world around them?

Multitasking

Younger children and teens frequently engage with more than one medium at the same time. According to a Kaiser Family Foundation study, one quarter to one third of all 8-18 year-olds surveyed said that they simultaneously use another medium while listening to music, using computers, reading, or watching TV. Moreover, 60% of 7-12th graders "talk on the phone, instant message, watch TV, listen to music, or surf the Web for fun" at least some of the time as they do homework (Garrison and Christakis, 2005, p. 23). When they are on a computer, 62% are also using another form of media and 64% are engaging in multiple computer activities at the same time.

The issue of multitasking with cell phone use and car driving is of particular concern. Concerns originally revolved around the act of having to pick up and physically manipulate the device—hence laws requiring hands-free headsets. However, as our treatment of attention above revealed, split attention goes beyond mere physical manipulation. Drivers chatting with a passenger typically pause when the traffic gets

rough, and the passenger respects the natural lull in the conversation; cell phone conversation partners do not. This split in attention and performance degradation is particularly problematic for inexperienced drivers. Teens also text-message while driving, and self-report that this activity is even more distracting than talking on the phone ("Cell Phones and Driving", http://www.iii.org/media/ hottopics/insurance/cellphones/). This finding makes sense from a cognitive science perspective. Behaviors in similar modalities interfere with each other more than behaviors in dissimilar modalities, suggesting that the visual-manual skill of texting interferes with the visual-manual skill of driving more than the audio-oral skill of talking interferes with driving.

What demands does multitasking make on a child? For many activities, true multitasking is impossible. Instead, we rapidly shift from on task to another, as required by the task or as our interest in one task wanes. A classic example is driving and talking at the same time. We can easily converse when the driving is simple—cruising on the highway—but may lose track of the conversation or stop speaking when the driving is complex—merging onto the highway in heavy traffic (Reisberg, 1997). In media multitasking, most people can't write an email and pay attention to a fast-moving TV drama at the same time. Instead, they write when the intensity wanes or during a commercial break. So instead of truly split attention, cognitive science has shown that we actually have attention that is mostly focused on one thing at a time.

How much of the non-attended channel penetrates into our awareness? If a person can easily switch one's attention to the non-attended channel, then it obviously will enter one's awareness. To avoid this kind of natural attention switching, psychologists devise tasks that are very difficult and require complete concentration to complete. Classic dichotic listening experiments have revealed that people have a very difficult time attending to two input channels at once (e.g. Cherry, 1953, cited in Reisberg, 1997). If subjects are taking dictation or repeating aloud the words spoken into their left ear, they have almost no awareness of the words spoken into their right ear.

Findings like these suggest that media multitasking will involve very little absorption of the secondary media, provided that the primary task is absorbing enough. So a child that is working diligently on her math homework with the TV on in the background will likely pay little attention and absorb next to nothing about the show. But what about when the primary task isn't completely absorbing and we try to switch our attention back and forth between two (or more) tasks?

Most research has shown that such task switching has its costs in terms of performance degradation. In

laboratory settings, subjects' responses were slower and more error prone after task switching than when compared to two similar trials in a row (Monsell, 2003). In another experiment, half of the students in a class were allowed to use their laptops to surf the web during a lecture while the other half had to keep their laptops closed (Hembrooke and Gay, 2003). Since listening to the lecture did not demand all of their concentration, students were able to switch the focus of their attention to their laptop as desired. As a result, they had poorer memories of the content of the lecture.

Combining a task that requires concentration with interruptions demanding an active response from the user—such as instant messages, email, or phone calls—causes the greatest performance degradation of all. Instant message conversations have been shown to increase errors in and slow the completion of web-browsing tasks (beyond the time it takes for the messages to be completed) in both desktop (Cutrell, Czerwinski, & Horvitz, 2000) and mobile phone settings (Nagata, 2003). Interruptions at work cause reduced productivity and efficiency, often due to people forgetting what they were doing pre-interruption and spending time re-familiarizing themselves with the previous task (Czerwinksi, Horvitz, and Wilhite, 2004).

How do we reconcile the findings from cognitive science that multitasking consistently degrades performance with the reports that multitasking is not just a habit, but a strong preference, of the teen generation (Prensky, 2001; Wallis, 2006)? People are often quite comfortable with task switching, which gives them the feeling they are efficiently multitasking, even though the total time taken during multitasking may be significantly longer than it would take to do each task one at a time. Stone suggests that we as a species may be cultivating a higher capacity for processing information from multiple channels. Compromised productivity and less than optimal efficiency is a price people are willing to pay to stay occupied.

More research is needed to determine the long-term effects of NDM engagement, especially for heavy users. For instance, does the pervasive availability of multiple activities impact personal concentration? Does sequential engagement with different tasks adversely affect attention? Does it engage the brain's pleasure centers and foster feelings of enhanced creativity or social connection? Or are heavy users seeking a breadth of information at the expense of a depth of understanding? Turkle muses, "We live a contradiction: Insisting that our world is increasingly complex, we nevertheless have created a communications culture that has decreased the time available for us to sit and think, uninterrupted. We are primed to receive a quick message to which we are expected to give a rapid response. Children growing up with this may never know another way" (Turkle, 2007).

NDM as toolbox

As we allow digital tools to assume our remembering for us, might the machines also take over some of the less pleasant, mundane tasks of production? Programs such as PhotoShop can simplify photographic production and eliminate comparatively clumsy darkroom techniques formally required for image manipulation. And spreadsheets can flawlessly compute numerical data, shifting human error from one's fingers on a calculator to one's command sequence in the program. These digital processes offer efficient methods of production with a small, if definite, loss in quality.

UWisc-Madison education researchers David Williamson Shaffer and Katherine Clinton suggest in their paper "toolforthoughts: Reexamining thinking in the digital age" (2005) that the NDM tools mentioned above shift what we need to know as humans from computational processes to new models of participation and sharing (Shaffer and Clinton, 2005). Shaffer and Clinton's text contributes to a contemporary intellectual community that links Vygotsky's concept of socially constructed cognition and the NDM with dramatic results: "We suggest that new computational tools problematize the concept of thought within current sociocultural theories by challenging the traditional position of privilege that humans occupy" (Shaffer and Clinton, 2005, p. 4).

Central to their thesis is the concept of a synergistic evolutionary trinity of man, tools and cognition: Shaffer and Clinton suggest that new NDM tools that facilitate collaboration are shifting creativity, cognition and memory from the individual to an external group or server, just as the shift from orality to print culture profoundly impacted how we engage with ideas. Humans will transfer many of the more computational and structural tasks (such as grammar and long division) to the NDM and gain more time and energy for collaboratively-based creative tasks. In one example, math students might analyze the motion of a rolling ball by employing spreadsheets, simulations, etc., without ever having to learn algebra. (ibid, p. 13). Given the explosive growth of the internet, why not offload the more computational tasks to a computer? "Both the brain and the Web have hundreds of billions of neurons (or Web pages)," write Kevin Kelly in a 2005 *Wired* article. "That adds up to a trillion "synapses" between the static pages on the Web. The human brain has about 100 times that number -- but brains are not doubling in size every few years. The Machine is." (Kelly, 2005, p. 4).

Others are not as sanguine about the future partnership between man and machine. Trevor Batten, a UK-based artist and media scholar, cautions against offloading our hard-won cognitive skills and highlights

the potential risk for abuse that putting too much power into the hands, or memory chips, of others. "We can become the helpless slaves of a commercial system based on the exploitation of our own ignorance, or we can attempt to become and remain the masters of our own destiny through knowledge and understanding" (Batten, 2006). For Batten, outsourcing such skills suggests a future where individual control and autonomy has been lost to broader collective or business interests who hold valuable computational and procedural knowledge.

One might argue that the embedded grammar and spelling applications in word processing programs are already altering how we write and how we judge writing. Rich Haswell of Texas A&M University summarizes the history of text-checking software " from self-controlled to automatic, from manifest to hidden", and suggests that the process has become virtually invisible to users. His comments parallel Turkle's earlier observations of the computer 's evolution from the PC as a programmable technophile's tool to the Macintosh's stylish if impenetrable surface interface (Haswell 2005; Turkle, 1995). Haswell outlines two divergent reactions to computer-based text checking tools in the education community. The first group judges student text errors more harshly; the second group is more lenient on text errors that "even a computer could not catch" (Haswell, 2005).

NDM as Institutional Memory Online

Personal memory has been referred to in this paper briefly with respect to how different types of NDM behaviors impact short-term and long-term memory, with different types and ways of engaging with NDM generally correlating to varying levels of attention and recall (Shat et al., 2004). But the institutional memory of the internet suggests that the medium itself has the potential to affect what we remember, what we forget, and why.

While links can break and web servers can crash, the vast majority of data uploaded to the web stays on the web until it is explicitly removed. But even once information has been overwritten or deleted, it may still exist in some form in the historical records of www.archive.org, which randomly archives millions of web pages containing material from those intended to have a short shelf life (such as a text chat) to more permanent information (such as Google Scholar). Socrates once lamented the decline of oral culture, fearing that print culture might delude readers into equating consuming information with truly understanding and internalizing knowledge; today, we encounter similar arguments with respect to print and the web, with three significant variables.

One, as the capacity of data storage hardware increases, there may be no practical limits as to the amount of information accessible and distributable via the NDM. As hardware becomes more compact, it may someday be possible to save the great works of literature on a web server or even a portable device. In time, entire libraries of information may accompany us wherever we go, accessible via an internet connection. In the freewheeling, unmonitored marketplace of ideas on the internet, cultural, economic, ideological and political considerations influence the quantity and quality information. At the 2006 Wikimania conference in Cambridge, MA, conference participants (and ardent Wikipedia supporters) noted that Wikipedia suffers from an unequal distribution of articles. The average contributor to the innovative online encyclopedia is a young, white, tech-savvy male, and topics in the humanities and the fine arts are not sufficiently represented ("Wikipedia Video", MIT New Media Literacies, 2007). For example, the text and images from the Wikipedia entry for "Leonardo da Vinci" fills twenty-one single-spaced pages, the entry for "internet" fills fifteen single-spaced pages, the citation for "parenting" fills eight pages, and the entry for "cooking" fills six. As the internet becomes the first stop for knowledge seekers, one wonders what will happen to all the information that is not accessible via the web, or is only available for a fee. Converting microfiche and other storage systems into an online format is currently a cumbersome and expensive process for libraries and publishers, especially in the absence of demand for this level of data conversion.

Second, how might we best engage with the internet's long, if selective, memory? What is the distinction between access to a seemingly unlimited library of material and the cognitive work needed to transition from 'reading' to 'understanding'? Memory is currently considered one of the cornerstones of personal development and cognition, but what if our memories were externally preserved indefinitely, ameliorating the need for personal remembrances?

Two emergent strategies suggest how we might deal with this overload of information in the future. The first approach is actively to prioritize what is worth remembering. "Endless engineer-hours are poured into stopping spam, but virtually no attention is paid to our interaction with our non-spam messages," opins online activist and author Cory Doctorow. "Our mailer… expends practically no effort on figuring out which of the non-spam emails are important and which ones can be safely ignored, dropped into archival folders, or deleted unread" ("My Thinkernet column on tools to help you forget things", http://craphound.com/?p=1923). In Doctorow's scenario, technology would help users to distinguish the useful or urgent from the less relevant. An alternate approach to managing the onslaught of online information is to synthesize it into useful cognitive "buckets".

SECTION IV

CONCLUSION, NEXT STEPS

What are some of the cognitive implications of approximately twelve million youth engaging in activities across NDM? The data are spotty at best. While Pew has data on the 12-17 year old cohort, it is not apparent whether these practices are being carried out at home, at school, or elsewhere. Are online teens uploading materials for class assignments and following the directions of an educator, or are they proactively creating materials reflecting their personal interests? How long are they spending on assignments? How invested are they in NDM production?

We began this research by asking whether NDM might be newly influencing the process of human cognitive development. We outlined the parameters of both digital media and cognitive science, mapped the known intersections between the two disciplines, and highlighted provocative questions generated by what is known to date and by what is not yet known and requires additional research.

As we have mentioned, research in the field of digital media is riddled with methodological traps (Jordan et al, 2007), more so than other fields of social science investigation; in addition to the problems associated with self-reporting, data collected online with reference to users, esp. the exaggerated ages reported by SNS users, are also suspect. Kaufman's Facebook research is an elegant attempt to construct a robust, quantitative research methodology, but even that model suffers from a few flaws. Another problem which bedevils online research is the lack of historicity on the web: new updates, system failures or hackers can change the content of a website literally overnight. The website archive.org periodically saves a version of a website, and with luck, one could retrieve some, if not all, of the lost information. Another serious handicap for publishing new research on NDM and cognition is the swift rate of change in the mediaverse. Sometimes, by the time the research is written up and published, technologies and youth have already moved on to the Next Big Thing. Existing results are often culled from studies of experienced new digital media users, and not a randomized sample of the general population.

The jury is still out on the possible impacts that NDM may be having on children's development. Children who use NDM as primary tools for social and recreational activities are increasingly independent, engaged in aspirational roleplay, adept at multitasking, less able to read real-life facial and social cues, and more comfortable with technology in general. However, it is unclear whether these attributes are truly changing how they think and engage with the world, or if these are temporary habits which will recede in importance or continue to evolve. Similarly, it is not clear from the available data

how many elements of the NDM relate to existing cognitive development categories. There has been evidence of high achievement at younger ages across different domains, but causality between elevated levels of achievement and NDM has yet to be established definitively. Are digital tools providing better training options, or are they accelerating the development process itself? For all the budding geniuses and well-educated children in the world, how many of them — and others — are ill-equipped socially and ethically to use their knowledge in a responsible, constructive, creative and personally fulfilling fashion?

And if it does turn out that digital media are affecting children's cognition and development in a positive way, what of the millions of children in the world who do not have access to these marvelous machines? As Jenkins, Gee, and others have warned, "access to this participatory culture functions as a new form of the hidden curriculum, shaping which youth will succeed and which will be left behind as they enter school and the workplace" (Jenkins et al., 2006). A 2005 Pew Internet survey reports that of the 14% of teens who report they aren't online come from poorer families and are likely to be of African-American descent (Lenhardt et al., 2005, p. i). This data stands in sharp contrast to teens living in households with a median income of more than $75,000 a year, who tend to not only have a home computer but also have reliable access to high-speed internet connection. One suspects that bridging this particular 'digital divide' will prove to be more complicated than distributing cheap solar-powered laptops to underprivileged children. Then there are the children who choose to engage with NDM minimally, if at all.

Regardless of the ultimate answers to these questions, we feel it is critical that the younger generation not be exoticized to the point of being transformed into alien beings. Despite the prevalence of IMing and social networking sites among teens, more than half (51%) still prefer talking on a landline telephone, and spending face time with friends versus communicating online (Lenhardt et al, 2005, iii). Children still play games, go to school, act out, cry, throw fits and engage in a host of other behaviors that generations of children have enacted before them. Children a generation or two ago may have decorated a treehouse or a dollhouse; children today now decorate virtual igloos and pet apartments. Children a generation ago may have played tag or loitered at the mall; children today play other games online or loiter at the virtual mall. Whether these new technological iterations of older behaviors are in fact changing the development process or are merely reinterpreting them remains to be seen. But it is important to acknowledge that they are just like children from past generations in many ways, if different in others.

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