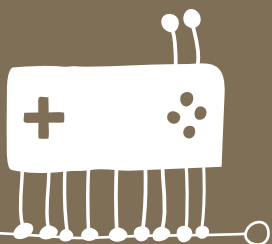# 2

Game changer:

Investing in digital play to advance children's learning and health

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The Joan Ganz Cooney Center at Sesame Workshop

The mission of the Joan Ganz Cooney Center at Sesame Workshop is to foster innovation in children's learning through digital media. The Center supports action research, encourages partnerships to connect child development experts and educators with interactive media and technology leaders, and mobilizes public and private investment in promising and proven new media technologies for children.

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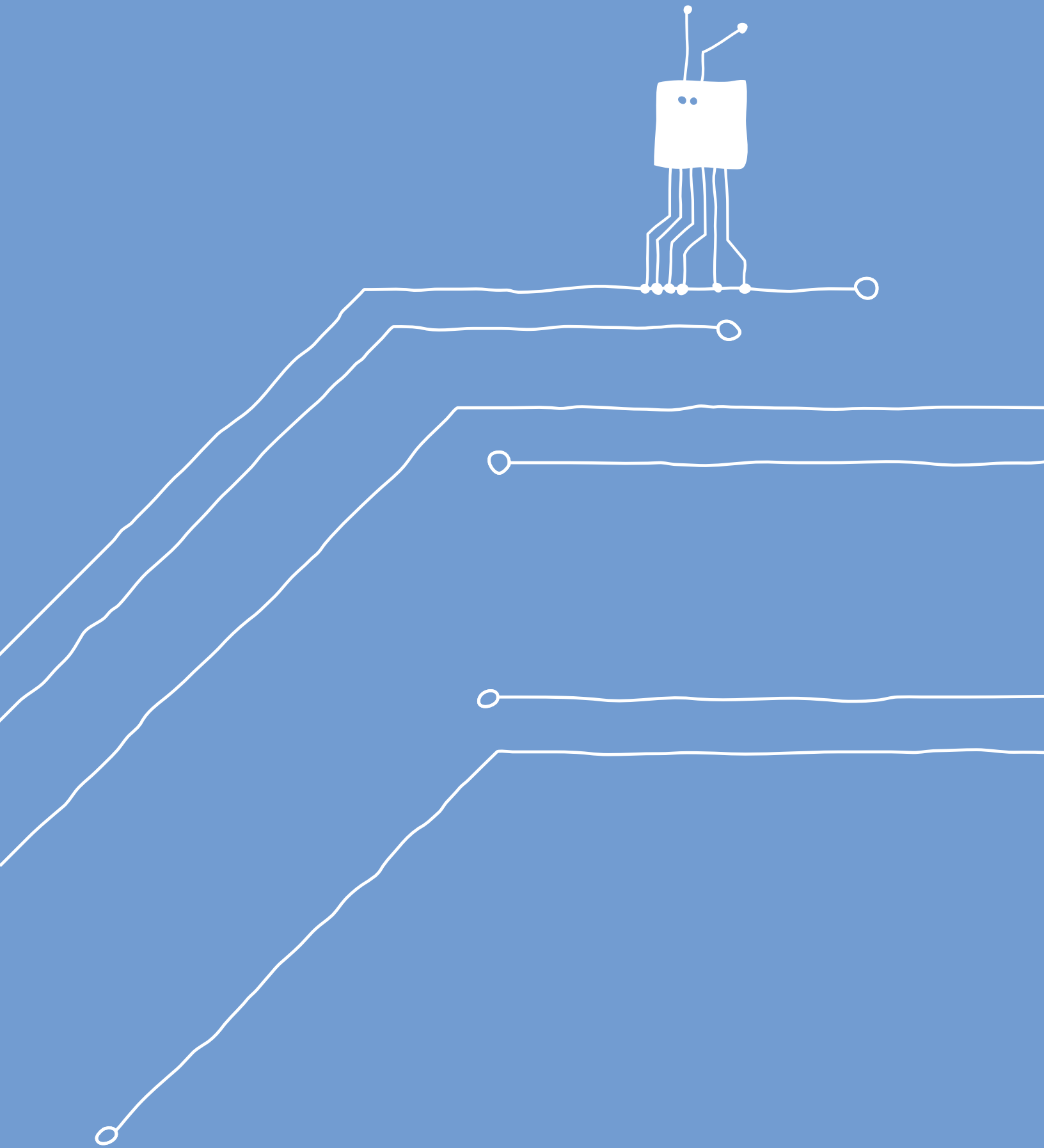
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contents

foreword

As younger and younger children participate in our ubiquitous media culture, researchers are debating the impact of digital games on children's learning and development. As University of Wisconsin professor Kurt Squire has written, "A generation of youth has grown up with games. Yet we know very little about what they are learning playing these games."

Games designed for a variety of platforms, including computers, televisions, and mobile devices, constitute a huge and growing market, dominated by products mainly for teens and adults. At the same time, we are now seeing a marked proliferation of digital games aimed at young children and "tweens." Many are marketed as educational, but as the Cooney Center's 2008 report *D is for Digital* concluded, parents, teachers, and other caregivers often have difficulty gauging which games are effective learning tools and determining how best to use them.

The need for more empirical research has led many adults to be concerned, with good reason, about their efficacy in educational environments. Some recent research confirms these fears: A meta-analysis conducted by the National Institutes for Health, Yale University, and Common Sense Media in late 2008 concluded that consuming large quantities of media, including video games, can contribute to children's health problems (Common Sense Media, 2008). Most parents regard some digital games with concern; popular titles such as *Grand Theft Auto* expose children to violence, sexual content, and inappropriate language.

The role of these media as a means to advance learning opportunities and healthy outcomes is gaining attention among key sectors in the United States, as well as in other nations. Can digital games, especially well-designed educational games, help reshape our nation's approach to learning and growing? For this inquiry, we interviewed a diverse group of experts in learning, health, and civic participation games — as well as scholarly skeptics — who are directly involved in research, design, and policy development in this nascent field. We asked them to share their professional knowledge of the potential of games-based technologies for addressing key learning and health challenges, and also to share their hopes and concerns for the future. We did not attempt an exhaustive literature review. Instead, we analyzed selected issues raised by the interviewees through consultation of scholarship and news sources. We also relied on an excellent recent review of learning and games by the MIT Education Arcade, titled *Moving Learning Games Forward*, and on the scholarship of other leading child development and game research scientists.

This report explores innovations from the commercial game industry and academic game labs, and examines pockets of experimentation in the classroom, health care, and other learning settings. We conclude that current approaches to solving key educational and child-health challenges insufficiently leverage the ubiquitous digital media that currently pervade children's lives. As the games and literacy expert James Paul Gee warned in our interview: "This is more than a Sputnik moment. We have to transform America back to a place that believes it has the tech and innovation savvy to tackle very large issues … like the modern-day version of going to the moon." We share this ambition and believe that the demonstrated potential of digital media, wisely guided by caring adults, could become a "game changer" in advancing children's prospects in the decade ahead.

Michael Levine, Ph.D.
Executive Director, Joan Ganz Cooney Center at Sesame Workshop

executive summary

Children are choosing to play digital games for hours during their leisure time. On an average day, children as young as eight spend as many hours engaged in media activity as they spend in school; three-quarters of American children play computer and video games.

Despite their reputation as promoters of violence and mayhem, digital games have in fact been shown to help children gain content and vital foundational and 21st-century skills. From digital games children can learn:

• Content (from rich vocabulary to science to history)
• Skills (from literacy to math to complex problem-solving)
• Creation of artifacts (from videos to software code)
• Systems thinking (how changing one element affects relationships as a whole)

Digital games can also be effective in improving children's health — from physical fitness and health promotion to disease management.

Digital games offer a promising and untapped opportunity to leverage children's enthusiasm and to help transform learning in America. The analysis offered here results from reviewing the literature and interviewing experts in the nascent field of digital learning.

Health and education

America's global leadership position depends on preparing the country's workforce to compete and collaborate effectively in the future. Two essential, intertwined components of creating a productive workforce are children's health and education. In both areas, the country faces opportunity and risk.

American children today are increasingly unhealthy at earlier ages, because:
- Too many do not eat properly, do not exercise enough, and are overweight.
- Childhood obesity and diabetes are increasingly prevalent.
- Childhood obesity and diabetes can lead to adult disease.

Significantly, poor childhood health is associated with poor academic achievement. Various research studies have associated better health and physical fitness with children's performance in school. Some schools are experimenting with maintaining dentists and doctors on-site or nearby to treat students (e.g., New York City's Harlem Children's Health Project at Harlem Children's Zone; the Mississippi Children's Health Project in the Mississippi Delta region), and the results are promising.

Digital games show significant potential to promote children's growth and healthy development. They can foster skills and knowledge that help children with academic learning, as well as habits that contribute to better health. Various types of games for health include:

Games for physical health
- *Dance Dance Revolution*, a commercially developed game, gets children moving physically for hours at a time, and has been adopted by several states for their public school physical fitness programs.

Games for developing healthy long-term habits
- *Sesame Street's Color Me Hungry* game teaches the importance of "eating your colors" by choosing fruits and vegetables.

- *Germinator* teaches children about germs and the biological rationale behind good hygiene habits.

Games for disease management
- *The Asthma Files* helps children use fewer steroid treatments for asthma and miss fewer days of school.
- *Re-Mission* helps educate young cancer patients about their disease and results in their greater adherence to medication regimens.

Need for strategic investment

All groups committed to the public interest — educators, policymakers, the federal government, industry leaders, philanthropies, universities — should invest resources in learning how to maximize the impact of a potentially powerful phenomenon that can advance both children's learning and health.

Experts in the field of digital learning interviewed for this study concluded that digital games have strong potential: Kids love playing them, but the research has not fully demonstrated with precision why or how they work, as well as how to design them for specific learning goals. Until more is known, our nation cannot fully harness their benefits. The issues we need to address include:
- Deepening the knowledge base about the benefits and limitations of games for children's learning;
- Designing games that increase learning, whether about health, literacy, science, history, or problem-solving;
- Identifying what elements (i.e., which settings, program interventions, or types of adult guidance) make game-playing more effective;
- Determining how games can best be integrated into the classroom and other learning environments.

The universe of digital learning is too large and too multidisciplinary to fit into old models of research and development. Currently, investment in digital media is haphazard and unfocused.

We need to maximize the potential of games in a more strategic way. To do this, we should organize research and investment strategies to:
• Establish research priorities.
• Study or scale up innovation in this arena.
• Disseminate evidence of what works.

Recommendations

The Joan Ganz Cooney Center recommends five steps to jump-start a national "game-changing" action plan to address the country's digital-age challenges in both health and education.

1. Implement R&D initiatives at federal and state levels

Research on digital media needs to be coordinated and collaborative throughout the country. We need to enable a research network across federal executive agencies to identify gaps and determine how practices from one content domain could be transferred to others.

In particular, we need better mechanisms to:
• Identify the learning gained through games and other digital media (e.g., R&D inventories).
• Develop rigorous design, practice, and performance metrics.
• Reach consensus and drive investment on high-priority research goals.

Leadership from government, industry, education, health, and philanthropy should:
• Convene regional summits, bringing together researchers, industry, philanthropy, and practitioners.
• Set priorities for research and development on digital media.
• Suggest allocations of new investments by the government and private sources.
• Invest in infrastructure that facilitates R&D collaboration. A promising initiative: National Public Lightpath proposes creating a national high-speed fiber-optic network to facilitate collaborations between researchers and organizations representing end-users.

The White House should lead the R&D effort by:
• Conducting an inventory to determine what research is being funded and by which agencies.
• Helping ensure interagency coordination of digital media activities and related research on learning by:
• Establishing a Subcommittee on Digital Media and Learning within the National Science and Technology Council (NSTC) under the Committee on Technology.

Federal research agencies should:
• Fund fellowships and model training programs to create a critical mass of scientists who specialize in games.
• Fund exploration of alternative assessment models that integrate digital learning approaches to high-priority needs (e.g., literacy, science, and math achievement gaps).
• Prepare a new meta-analysis of existing research on the positive impacts of games and other digital media on children's health and learning, leading to recommendations for further research.
• Establish a national "best practices" initiative to disseminate effective uses of games technologies for education and healthy development.

2. Create innovative partnerships

We need to establish innovative methods to fund and stimulate creative networks of partners with different areas of expertise. The federal government and philanthropies should provide incentives to create new types of partnerships. Possible models include:
• The public-private partnerships that the Department of Defense has forged with technology partners and game developers;
• The National Center for Research in Advanced Information and Digital Technologies, a nonprofit corporation organized within the Department of Education;
• Multi-stakeholder partnerships between game makers, foundation-supported nonprofits, and government funding;
• "Double-bottom-line" companies that seek both social impact and return on capital investment.

3. Support adult guidance for children's digital activities

Even more important than the advances of technology itself (the hardware and software) is the human infrastructure needed to make new technology useful for children's learning.

Children need adult support
- Adults can offer the context, perspective, and encouragement that children lack and need.
- Teachers, parents, health professionals, and afterschool providers should be trained to use and understand the benefits and limitations of digital games.

Training for adults should include:
- Outreach to parents to make research understandable;
- Professional development for teachers on how to integrate games into curriculum;
- New protocols for community health providers to promote children's "healthy habits."

The country should create a "digital teacher corps" modeled on initiatives such as Teach for America. The goals would be to:
- Build professional capacity.
- Enable educators to help students learn to transform information into knowledge used for discovery and problem-solving.
- Engage students in an environment that teaches skills, content, and new ways of thinking.

4. Modernize public media

Educational television media for young children have a strong track record of enhancing basic skills (basic reading and math) as well as more complex skills (social, emotional, and problem-solving) for all children, but especially for those from underserved communities. These television-based efforts should now be modernized to accommodate the needs and interests of children living in a digital age as well as to leverage the hundreds of millions of dollars of previous public investment in educational programming for children.

Educational media companies should:
- Expand current experimentation with new formats (such as games and mobile learning) to teach children both traditional literacy and new 21st-century skills.
- Create new business models and incentives to ensure the wide distribution of media to schools and other learning centers.

5. Initiate a broad public dialogue about digital media and games

Public dialogue on children's digital games often focuses on violence, sexual content, inappropriate language, and safety. We need to engage the public on the potential benefits of digital media. Engagement efforts might include:
- Creating and publishing parent guides to digital media in magazines and newspapers;
- Holding "town hall meetings" and "summits" for parents and the general public;
- Expanding media literacy curricula in schools.

Conclusion

Digital games are here to stay and offer the country a rare opportunity to leverage children's already established enthusiasm in order to reform education and promote healthy development. We know enough about digital games and how they work to recognize their promise. Now we need to invest time and resources to turn this promise into a real "game changer" for America's children.

"A sound mind and a sound body is a short but full description of a happy state in this world."

John Locke

The current financial crisis has forced Americans to face a stark reality — our future as the world's innovation leader requires bold steps to stabilize the economy and to prepare a workforce that can compete in a global age. President Barack Obama has called for a "new foundation" for America that emphasizes a vital "down payment" for future economic growth through transformations in education and health care. The President properly recognizes the primacy of early intervention and prevention as the foundation for lifelong success: Nurturing our most vulnerable children beginning in early childhood must be a central strategy.

Education and children's health, beginning as early as at conception, are inextricably intertwined (Hamburg 1992; Fiscella & Kitzman, 2009). Prenatal care and supports for early life growth and nutrition have been proven to have a positive impact on a child's social and academic development (Grantham-McGregor, 1995; Yanney & Marlow, 2004; see Box 4). Poor health in children has consequences that influence all aspects of their learning and development. Preventable health problems lead to children's poor academic achievement and diminishes their long-term economic prospects in adulthood (Crimmins & Saito, 2001; Ryan, 2009).

In the face of pressing national challenges, we must not recycle ineffective approaches to learning and health care that have left millions of children at risk. *Game Changer* suggests that public- and private-sector investments must change course, starting now, to deploy emerging technology that is increasingly influential in children's lives. Digital media have dramatically transformed children's play. From the preschool years on, millions of American children are actively immersed in play within a new, virtual playground. Studies by the Kaiser Family Foundation and Sesame Workshop have found that on an average day, primary-school children spend as many hours engaged in media activity as they spend in school (Kaiser Family Foundation, 2005; Sesame Workshop, 2009). The Entertainment Software Association (2009) tells us that three-quarters of all American children play computer and video games, and, according to the market research firm NPD (2008), children start engaging in video game play at approximately 6 years of age. Playing digital games, feeding virtual pets, and fashioning online identities have become second nature to many of these "digital natives."

Current research on games and learning

Research now offers solid evidence that children learn important content, perspectives, and vital "21st-century skills" from playing digital games. This research documents the potential of digital games and provides a broader view of the medium — beyond the public's overwhelming focus on research that explores its harmful effects on children (see p. 52 for Selected Literature).

Sea changes in the game industry, a growing body of games scholarship, and pockets of experimentation in the classroom, in health care, and in other learning settings provide clues as to how games might be deployed in the interest of children's well-being (Kirriemuir & McFarlane, 2004; Gee, 2008; Shaffer, Squire, Halverson, & Gee, 2005; Klopfer et al., 2009; see Appendices A and C).

> **Box 1: Games for a digital age**
>
> A voluntary activity structured by rules, with a defined outcome (winning, losing) or other quantifiable feedback (e.g., points) that facilitates reliable comparisons of in-player performances.
>
> **Digital game:** A game played by manipulating some form of electronic media (computer, game console, cell phone). Digital technology allows games to be played across media, time, social spaces, and networks of meaning.
>
> **Digital-learning game:** Differing from both games of entertainment and games for training, targets the acquisition of knowledge as its own end and fosters habits of mind and understanding that are generally useful or useful within an academic context.
>
> (Source: Klopfer, Osterweil, & Salen, 2009)

James Paul Gee, of Arizona State University, who is spearheading the development of a civic participation game called *Our Courts* with retired Supreme Court Justice Sandra Day O'Connor, points out that "Good video games incorporate good learning principles, principles supported by current research in cognitive science" (Gee, 2003, 2004). Well-designed video games encourage learning by allowing players the freedom to fail and experiment in a complex system; they also offer opportunities to develop 21st-century skills, which students must master in order to succeed in a knowledge-based economy (see Box 2). Colleen Macklin of Parsons The New School for Design sees games as one element of a larger ecology that supports learning outside the game itself. She describes games as being portals to new learning by allowing children opportunities to do things such as explain a game to a parent, help younger siblings with strategy and problem-solving in a game, or develop interests around the content in a game to support learning, communication, and language skills (Macklin, 2009).

Debra Lieberman, a communications researcher and Director of the Health Games Research national program at the University of California, Santa Barbara, reviewed the research literature on games and learning (Lieberman, 2006b) and grouped outcomes into nine categories of learning (see Box 3).

In examining the new scientific research on learning games, we also found an emerging body of scholarship indicating that digital games offer unique ways to improve children's health. Consider *Dance Dance Revolution* (DDR), which has reached thousands of children as young as kindergartners and motivated them to exercise for hours at a time. Several states are incorporating DDR into their public school fitness programs. Another standout in the health games field is *Re-Mission*. Young cancer patients who played this game, in addition to receiving standard care, showed greater cancer-related knowledge acquisition, self-efficacy, and a greater adherence to medication regimens (Kato, Cole, Bradlyn, & Pollock, 2008; Tate, Haritatos, & Cole, 2009).

! Box 2: Preparing for tomorrow … today

Project New Media Literacies director Henry Jenkins urges educators to provide experiences to integrate digital media and promote the following skills:

Play: The capacity to experiment with one's surroundings as a form of problem-solving.

Performance: The ability to adopt alternative identities for the purpose of improvisation and discovery.

Simulation: The ability to interpret and construct dynamic models of real-world processes.

Appropriation: The ability to meaningfully sample and remix media content.

Multitasking: The ability to scan one's environment and shift focus as needed to salient details.

Distributed Cognition: The ability to interact meaningfully with tools that expand mental capacities.

Collective Intelligence: The ability to pool knowledge and compare notes with others toward a common goal.

Judgment: The ability to evaluate the reliability and credibility of different information sources.

Transmedia Navigation: The ability to follow the flow of stories and information across multiple modalities.

Networking: The ability to search for, synthesize, and disseminate information.

Negotiation: The ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms.

(Source: Jenkins, Clinton, Purushotma, Robison, & Weigel, 2006)

This paper describes expert perspectives on the promise of digital games to contribute to children's health specifically, and to children's learning in general. It suggests a new national strategy to explore the potential of digital technologies to help transform our current learning and health practices.

> **Box 3: Benefits of research-based game play**
>
> **Nine areas of learning and behavior change supported by well-designed interactive games:**
> · Motivation to learn
> · Perception and coordination
> · Thinking and problem-solving
> · Knowledge
> · Skills and behaviors
> · Self-regulation and therapy
> · Self concepts
> · Social relationships
> · Attitudes and values
>
> (Source: Lieberman, 2006b)

American children today are facing increasing health risks at earlier and earlier ages. Too many don't eat properly, don't exercise enough, and are overweight, all conditions that lead to long-term health problems.

Preteen obesity has reached epidemic proportions. The percentage of overweight children in the U.S. has doubled in the past decade. U.S. childhood- and adolescent-obesity rates in the current decade have been estimated at close to 30%, compared to 20% in most of Western Europe (Popkin, 2005). Before the 1990s, 95% of pediatric diabetes patients were type 1, which is congenital; today, as many as 45% of U.S. pediatric patients diagnosed with diabetes in the U.S. may be type 2, which is strongly linked to obesity and poor diet (American Diabetes Association, 2009). Ominously, childhood obesity is associated with the development of cardiovascular disease and diabetes in adulthood (Dietz & Robinson, 2005). Low-income children are more at risk for developing health problems than are middle-class children; the overall prevalence of obesity among poor children is 50% higher than among their middle-class peers (Miech et al., 2006).

Asthma is another growing problem for American children. In 1980, 3.6% of children had asthma, but by 2007, the figure had risen to 9.1%. In addition, African-American children are 1.6 times more likely than white children to have asthma, but 7.6 times more likely to die from asthma than are white children (Akinbami, Moorman, Garbe, & Sondik, 2009).

! Box 4: Middle childhood and health

Obesity
- The percentage of overweight 6-to-11-year-olds in 2003–2006 was more than four times higher than in 1971–1974 (17% and 4%, respectively).
- Boys and girls are about equally likely to be overweight, though Mexican-American boys are significantly more likely than white boys to be overweight. African-American girls are more likely than white girls to be overweight.
- Obese children are at risk for being obese adults. In addition, childhood obesity may have immediate consequences, such as socio-emotional issues and some cardiovascular-disease risk factors, such as abnormal glucose tolerance and elevated blood pressure.

(Sources: National Health and Nutrition Examination Survey, 2009; Centers for Disease Control, 2009)

Diabetes
- Currently, more than 26,000 5-to-9-year-olds have diabetes.
- About 150,000 young people under 18 years — or about one in every 400 to 500 — have diabetes.
- Health-care providers are finding more and more children with type 2 diabetes, a disease usually diagnosed in overweight adults.

- Children who develop type 2 diabetes are typically overweight or obese and have a family history of the disease. Rates are higher among American Indian, African-American, Asian, and Hispanic/Latino groups.
- People with diabetes (types 1 and 2) are at great risk of developing serious health complications over time, such as heart disease, kidney disease, blindness, and stroke.

(Source: SEARCH for Diabetes in Youth, 2009)

Asthma
- According to data gathered between 2005 and 2007, 10.1% of all 5-to-9-year-olds were reported to have asthma. Puerto Rican and African-American children had significantly higher rates (21.5% and 14.9%, respectively).
- Low-income populations, minorities, and children living in inner cities experience more emergency-room visits, hospitalizations, and deaths due to asthma than the general population.
- Asthma is one of the leading causes of school absenteeism.

(Sources: Environment and Human Health, Inc., 2009; Healthy People 2010, 2009)

Obesity, asthma, and other diseases impede children's academic performance. Studies have found that overweight children do worse in school and are also less successful later in life (Gortmaker, Must, Perrin, Sobol, & Dietz, 1993; Datar, Sturm, & Magnabosco, 2004; Datar & Sturm, 2006). Children with asthma miss school more often, which is linked to lower academic performance (Moonie, 2008). Further, as these children become adults, they significantly burden the health-care system.

Health habits have long-term consequences and thus should be addressed in the early years. Studies have shown that obese children are more likely to become obese adults (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997; Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001). Other research has found that children as young as infants and toddlers begin to develop habits which contribute to obesity, such as consuming too many high calorie foods and too much sodium (Mathematica Policy Research, 2006). If children are overweight before age 8, obesity in adulthood is likely to be more severe (Freedman et al., 2001).
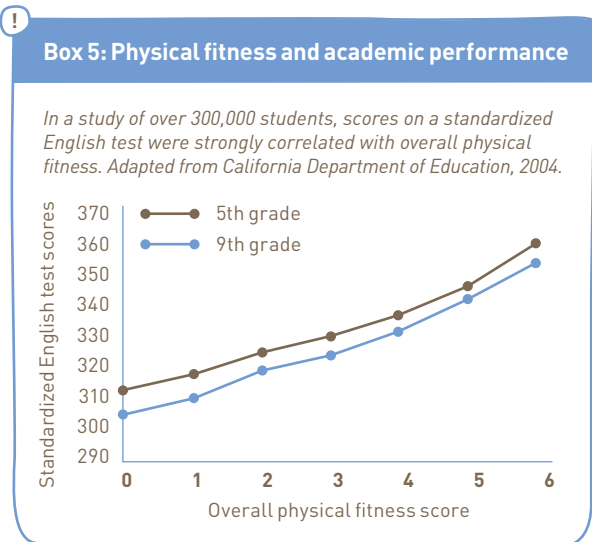
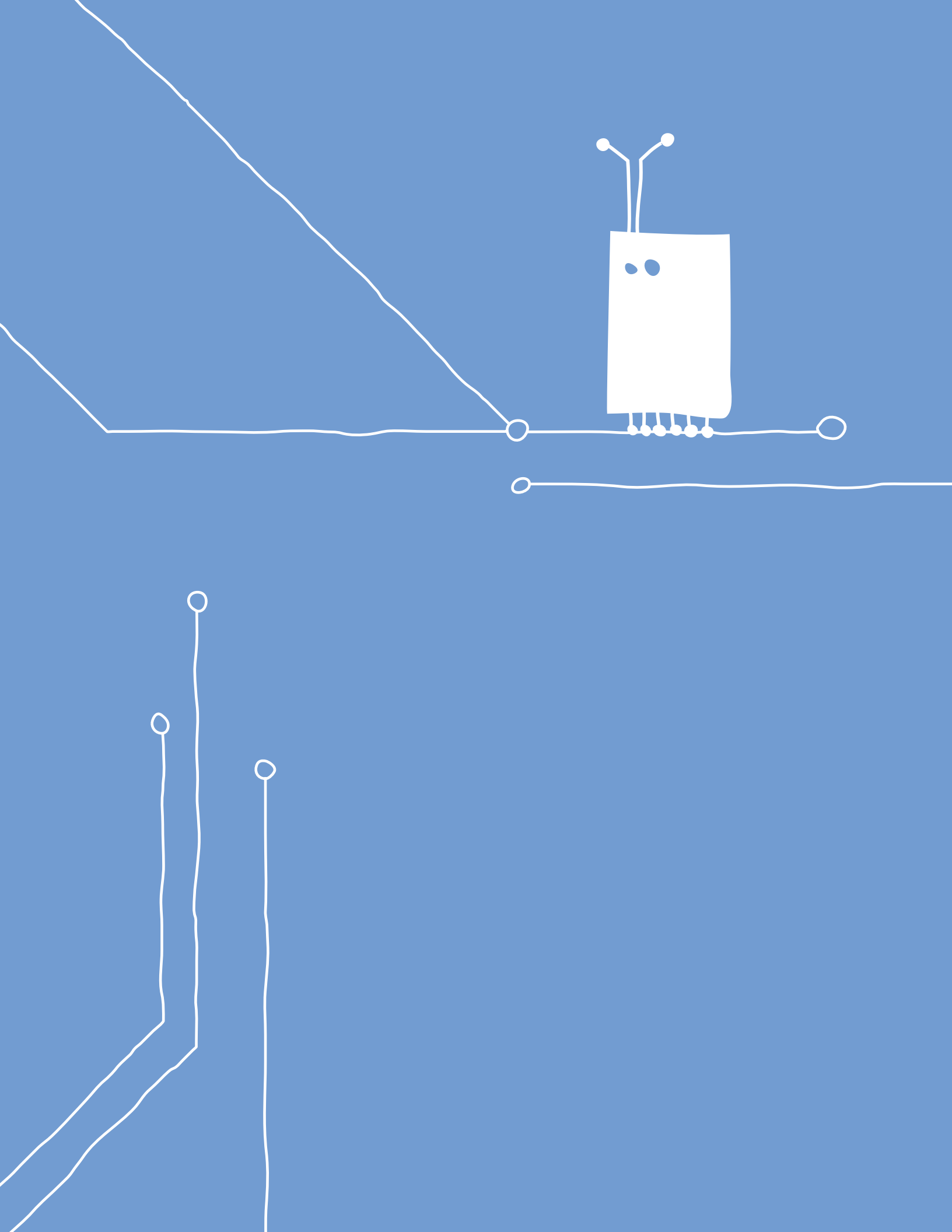## Connecting children's health to learning

Common sense tells us that a child who must stay home from school due to untreated asthma will learn less than a child who is present. Some schools are already experimenting with maintaining doctors and dentists on-site to treat students, and the results are promising. The Harlem Children's Health Project at Harlem Children's Zone is a school-based health center that provides medical, dental, and mental-health services, all under one roof. The Mississippi Children's Health Project provides social and medical services to children in remote rural communities of the Mississippi Delta region through a combination of school-based, fixed-site, and community-outreach service strategies (Children's Health Fund, 2009). The Kellogg Foundation launched the five-year School-Based Health Care Policy Program in 2004, supporting the National Assembly on School-Based Health Care and nine of its state affiliates (NASBHC, 2009). Several hundred schools in the United States now have on-site clinics or have formal links to health facilities for students' care.

Improving student health through school-based programs appears to improve children's academic performance (Hawkins, Catalano, Kosterman, Abbott, & Hill, 1999; Kleinman et al., 2002; Hawkins, Kosterman, Catalano, Hill, & Abbott, 2005; Rampersaud, Pereira, Girard, Adams, & Metzl, 2005; Murray, Low, Hollis, Cross, & Davis, 2007). Studies have also found direct links between school-based health centers (SBHC) and learning readiness. One study found that African-American male SBHC users were three times more likely to stay in school than their peers who did not use the clinic (McCord, 1993). Another study found that SBHCs contributed to reducing hospitalization and increased school attendance among inner-city school children with asthma (Webber, 2003; NASBHC, 2009).

Most experts believe that children who eat healthfully and are more physically active are also able to learn more easily (van Sluijs, McMinn, & Griffin, 2007; Taras & Potts-Datema, 2005; Naylor & McKay, 2009). Some studies have shown a strong association between children's physical fitness and academic performance (California Department of Education, 2004; Chomitz et al., 2009; see Box 5).

Among children at risk for poor health outcomes, evidence is increasing that their wholehearted embrace of digital games may provide a critical new method to promote healthy habits in early childhood, with significant long-term impact.

Box 5: Physical fitness and academic performance

In a study of over 300,000 students, scores on a standardized English test were strongly correlated with overall physical fitness. Adapted from California Department of Education, 2004.

games for health

Well-designed digital games show significant potential to promote children's growth and healthy development. They can foster skills and knowledge that help children with academic learning, as well as habits which contribute to better health.

Leaders in the emerging field of "games for health" are exploring how to best deploy digital media in various settings, hoping to inculcate good habits, beginning in early childhood (Lieberman, in press).

For example, in 2007, the Robert Wood Johnson Foundation's (RWJF) Pioneer Portfolio established a Health Games Research national program to fund research projects that investigate processes of learning and behavior change with health games in order to advance the design and effectiveness of future health games for all age groups (see Box 6 for other efforts).

Box 6: Communities of practice: Serious Games, Games for Change, Games for Health

In 2002, the Woodrow Wilson International Center for Scholars, in Washington, D.C., launched the **Serious Games Initiative** (seriousgames.org) to encourage the development of games that address policy and management issues. More focused alliances began to appear two years later, including **Games for Change** (gamesforchange.org), which considers social issues and social change, and **Games for Health**, which addresses the design and use of digital games to improve health behavior and the delivery of health care.

Based in New York City, **Games for Change** provides support, visibility, and shared resources to individuals and organizations using digital games for social change. The work includes providing an entry point for nonprofits and foundations new to the field. G4C also serves as a coordinating hub for collaborative investment and evaluation of social-change games projects.

The focus of the Washington, D.C.-based **Games for Health** (gamesforhealth.org) is to develop a community and best-practices platform for the numerous games being built for health care applications. The project has brought together researchers, medical professionals, and game developers to share information about the impact that games and game technologies can have on health care outcomes.

Box 7: Play better, live longer: Health e-games

Health e-games include games and training simulations designed to increase health literacy, influence behavior change, and promote professional education. To qualify as a health e-game, the experience must be fun *and* deliver health benefits, including health literacy, physical fitness, cognitive fitness, skills development, and condition management. Health e-games are often used as tools to promote healthful behaviors, such as regular exercise, stress reduction, smoking cessation, adherence to doctor-recommended medicine usage, weight management, healthy eating habits, or other positive lifestyle changes.

The health e-games market is comprised of four consumer categories and one professional area, including:
- Exercise games (Ex: fitness, coaching, health promotion)
- Brain fitness (Ex: cognitive fitness, brain training)
- Condition management (Ex: diabetes, asthma, cancer, pain management)
- Healthy eating (Ex: weight management, obesity)
- Professional training (Ex: simulations for training surgeons)

Health e-games are estimated to be a $6.6 billion market segment, with growth being fueled by two primary market forces: (i) the popularity and commercial success of Nintendo's interactive exergames for Wii and Wii Fit and (ii) the growth of the casual gaming market.

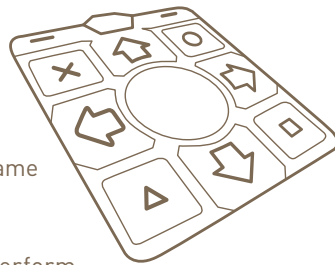(Source: Donner, Goldstein, & Loughran, 2008)

Foundations such as RWJF, health insurers such as Humana, venture philanthropists such as Pam Omidyar, and investors such as Physic Ventures have primed a "health e-games" sector (see Box 7). These early efforts have demonstrated the many ways that well-designed, evidence-based health games can captivate and motivate children and adults to engage in, for example, physical activity, healthy lifestyle choices, chronic-disease self-management, and adherence to medical treatment plans.
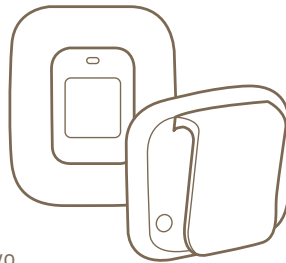
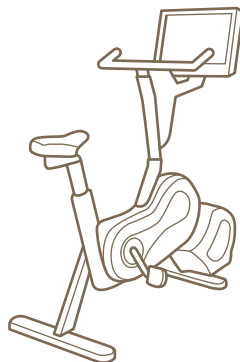## Box 8: Sound body, sound mind: A primer on promising exergames

Possibly the most well-known exergame is Konami's *Dance Dance Revolution*, in which players perform multi-step dance combos on a dance pad according to cues on a screen.
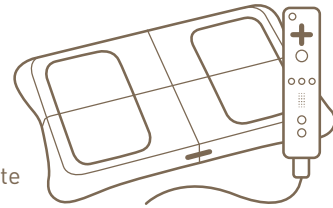
Nintendo recently released *Personal Trainer: Walking*, which comes with two "Activity Meter" accessories that record every step users take and when they take it. Data is then sent wirelessly to a Nintendo DS/DSi system and compiled into interactive graphs that help users set goals and see their progress over time.
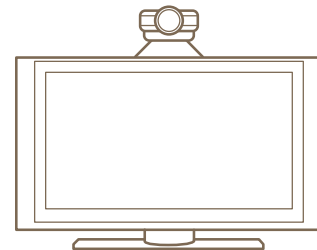
Bicycling interfaces are also popular, exemplified by titles such as the *Upright Youth Bike*, *CycleScore*, and *Cateye GameBike*.

Nintendo's popular *Wii Fit* is designed to promote fitness and weight management for people of all ages. Users hold a Wii-mote and stand on a pressure-sensitive Wii Balance Board to participate in various yoga, strength, aerobic, and balance exercises, as well as mini-games. The Wii Fit also tracks users' daily progress and usage patterns. Through their personal profiles, users can set goals, view body-mass-index results over time, and enter exercise time done outside of Wii Fit. An enhanced version, the *Wii Fit Plus*, is due out fall 2009, featuring new workout activities, new minigames, and the ability to string exercises together without any interruption.

Unlike the Wii system, which employs user-designed avatars (called "Miis") on the screen, *EyeToy* games use a TV-top camera pointed at the player to insert the player's actual image into the on-screen game environment. Players move their "character" simply by moving in front of the camera. *EyeToy: Kinetic* is an exergame that offers a variety of workouts, ranging from combat and karate to toning and tai chi. A virtual trainer moves the player through a 12-week program, and the player's progress can be saved and reviewed.

(Source: Lieberman, 2006a; Montero & Gonen, 2009)

Games for physical fitness

Medical researchers have begun to investigate how physical activity games might address America's childhood obesity epidemic. Exergames, or games that require physical exertion, have shown particular potential to get children moving (see Box 8).

An estimated several hundred schools in at least 10 states are using *Dance Dance Revolution* (DDR) in the fight against childhood obesity (Schiesel, 2007). Research by the Mayo Clinic found that children playing *DDR* expended significantly more energy than those watching television or playing more traditional video games (Lanningham-Foster et al., 2006). Other studies found that exergames not only increase energy use but also reduce biochemical and physiological markers of obesity (Tan, Aziz, Chua, & Teh, 2002; Unnithan, Houser, & Fernhall, 2006; Murphy et al., 2009). Maloney and colleagues (2008) observed actual long-term behavioral changes. In a seven-month study, they found that children who were randomly selected to receive an intervention with exergames reported significantly higher levels of vigorous physical activity.

Humana Games for Health has experimented with using both real and virtual play to promote physical fitness with its *Horsepower Challenge*, a physical activity game that was piloted in Kentucky public schools in 2008. Middle-school students compete in an online race "around the world"; each student wears a pedometer to record his steps, the total number of steps per team is computed, and the team with the most steps wins. Research on the game's impact indicates an average of a 23% hike in students' activity levels; 62% of students reported that they exercised more during the time span of the challenge and during the pilot; and 45% of the participants reported that they ate more healthfully because of the challenge, although there are no nutritional messages within the game itself (Humana, 2008).

Exergames, while promising, are hardly a panacea for our nation's childhood-obesity problem. Like many children's activities, they are most effective when accompanied by adult guidance and, for at-risk populations, should be part of more robust health-education interventions. A UCSF study found that life stressors such as family illness and incarceration of a family member frequently prevented low-income children from using *DDR* to enhance physical activity at home (Madsen, Yen, Wlasiuk, Newman, & Lustig, 2007). Furthermore, when studying children playing *Wii Sports*, Graves et al. (2007) found that Wii players expended significantly less energy than children playing "real-life" sports.

While existing research shows that exergames can improve physical fitness, their potential to improve learning and health outcomes needs to be explored more deeply. Both game makers and academics should investigate how to use this new genre to help children form healthy habits and achieve more significant levels of physical activity.

Games for healthy habits

Helping children develop sound habits, such as good nutrition, hygiene, and the ability to make healthy choices, is critical to reducing the prevalence of childhood obesity and associated adulthood diseases. Traditional modalities such as comprehensive school-based health education programs have had demonstrated impact in improving children's overall health (Murray, Low, Hollis, Cross, & Davis, 2007). Very few games have been designed to encourage healthy habits in young children, but research suggests that a number of game innovations designed for other audiences could be embedded in more traditional delivery systems and are likely to contribute to better health outcomes.

Among the handful of children's games to tackle issues related to obesity are those on the website Playnormous, which offers games that parents and young children can play together. *Food Fury*, for example, challenges players to distinguish between healthful and less-healthful foods as a timer forces fast choices. *Sesame Street's Color Me Hungry* combines game play with a campaign called "Healthy Habits for Life" to help children make healthy food choices.

Available on the *Sesame Street* website, preschoolers learn the importance of "eating your colors" by choosing fruits and vegetables. Anchored by content broadcast on *Sesame Street*, such as the Muppet character Cookie Monster learning that "cookies are a sometimes food," the campaign reinforces children's learning and skill development for making healthy choices, using multimedia materials and activities designed for parents, caregivers, and children.

Because television remains the dominant form of media among 6-to-9-year-olds, using familiar television characters in learning and health games could serve these efforts well (Sesame Workshop, 2009). Like *Sesame Street*, the PBS television show *Fetch* ties its curriculum-based content to online games to reinforce children's learning. Funded by the National Science Foundation, the *Fetch* game *Germinator* on the PBS KIDS website teaches children about germs and the biological rationale behind good-hygiene habits. The online games buttress the curriculum by corresponding to themes introduced on the national broadcast each week. *Sesame Street* and *Fetch* demonstrate how learning and health games might be embedded and distributed within existing and new public media efforts.

Academic research in this area is scant. One recent, small-scale study from Michigan State showed that youth playing the healthy-eating game *Rightway Café* for only 40 minutes knew more about nutrition and intended to make healthier food choices up to one month later (Peng, 2009). An eight-week study of 209 fourth-graders using a school-based CD-ROM educational program showed decreases in body-mass index in girls, but not in boys, and a modest increase in physical activity among both girls and boys (Goran & Reynolds, 2005). A large, controlled study of 1,500 elementary aged students in Houston schools showed that *Squire's Quest!*, a 10-session PC-based multimedia game about a squire's advancement to knighthood through healthful eating, led to significantly increased consumption of fruit and vegetables (Baranowski et al., 2003).

Games for disease management and prevention

Games can improve children's learning, health behaviors, and health outcomes in the areas of disease management and disease prevention. Reviews of current research literature (Baranowski, Buday, Thompson, & Baranowski, 2008) and well-designed research studies (Bartholomew et al., 2000; Brown et al., 1997) have demonstrated the capacity of games to promote better self-management of chronic conditions.

For example, several games have been designed to improve health behaviors related to asthma, a disease affecting millions of American children, particularly African-Americans residing in inner cities (Environment and Human Health, Inc., 2009). McPherson et al. (2006) developed *The Asthma Files*, a decision-and-content-based CD-ROM game for children with asthma in the U.K. At a six-month follow-up, researchers found that children who played the game used fewer steroid treatments for asthma and missed fewer days of school, compared to their peers in a control group. Another trial showed that an interactive game called *Watch, Discover, Think, and Act* decreased hospitalizations and increased functional status among children with asthma (Bartholomew et al., 2000). Randomized trials of the Super Nintendo asthma self-management game *Bronkie the Bronchiasaurus* found significant reductions in young players' asthma-related urgent-care and emergency-room visits, missed school days, and parents' missed work days (Lieberman, 2001).

Games have also helped children self-manage type 1 diabetes (an autoimmune disease unrelated to type 2, which is associated with obesity) through decision-making and food choices. In addition, they can lessen the stigma associated with having a chronic condition, increasing communication with family and peers about diabetes, and, as a result, improving adherence. One Japanese study found that children who used diabetes-management games demonstrated better knowledge of blood-glucose monitoring and insulin dosing at a six-month follow-up (Aoki et al., 2004). Another promising game is *GlucoBoy*, for the Game Boy Advance and Nintendo DS, that combines a

blood-glucose monitor with access to games (there is more access when the player's own blood-glucose levels are in the normal range) to increase the social acceptability of glucose monitoring and thereby improve self-management (Slater, 2005). The Super Nintendo diabetes self-management game *Packy & Marlon* was tested in a six-month clinical trial, which found that diabetic children and adolescents who were randomly assigned to take home the diabetes game reduced their diabetes-related urgent-care and emergency-room visits by 77%, compared to no change in the group randomly assigned to take home an entertainment video game that had no health content (Brown et al., 1997; Lieberman, 2001).

In addition to developing and studying games that improve self-care and disease self-management, researchers and game publishers are developing games to improve patient adherence to treatment plans. HopeLab's *Re-Mission*, a third-person-shooter game, is designed to educate young cancer patients about their disease and encourage them to take an active role in treatment. Players accompany Roxxi, a nanotech warrior designed to fight disease at the cellular level, on her missions through the human body, shooting malignant cancer cells and battling the side effects of cancer and cancer treatments. Results from a 34-site international research study of 374 adolescent and young-adult cancer patients found the game to be highly effective; players showed a 70% faster acquisition of cancer-related knowledge, a three-fold greater rate increase in cancer-specific self-efficacy, and a greater adherence to medication regimens (Kato et al., 2008; Tate et al., 2009). Given demonstrable improvement in cancer-related health outcomes, HopeLab plans to generalize their "play-based behavioral intervention" approach to other conditions such as obesity, major depressive disorders, sickle-cell disease, and autism.

Health Games Research, the $8.25 million national program funded by the Robert Wood Johnson Foundation's Pioneer Portfolio, is awarding grants to about 25 organizations to conduct groundbreaking research to discover how and why players respond to features of health games, with the goal of identifying theory- and evidence-based principles that can be applied in the design of future health games. Many of the Health Games Research grantees are including children, adolescents, and families in their research, so much will be learned about game design principles and strategies that motivate young people to improve health behaviors and outcomes.

Games for public health

Health-games advocates believe they can contribute to a wider public-engagement purpose: helping the general public understand key health issues. The U.K.'s Channel 4 has used games such as *Sneeze*, in which players attempt to infect a specific percentage of people in a public space, to disseminate information about flu and flu prevention. Other public-health games include Persuasive Games' *FATWORLD*, designed to teach users about the politics of nutrition and the wide-scale, long-term impact of poor health choices, and *Food Force*, which is designed to make players aware of global food shortages and policies that can help address world hunger.

The need for more research on health games

These pockets of research provide promising evidence that point to important and concrete ways to deploy games to target specific health goals. However, more research is needed, with planned and varied interventions, robust sample sizes, longer time horizons, and engaging game technologies to explore the full potential of games to promote healthy development and lowering the risk of childhood disease. A rigorous, large-scale research program may yield significant benefits and be well worth undertaking.

The power of learning games

Health games are an important component of the burgeoning world of digital games. What we know about health games is a microcosm of what we know, and don't know, about learning games in general.

We know that digital games of all sorts are entrancing millions of American children (see Box 9). Games are by definition fun and voluntary, and kids play them eagerly for hours on end. Players are learning skills and content during these hours devoted to conquering a variety of games. Well-designed learning games provide players with opportunities to acquire various skills and useful information, from how to improve their reading skills to how to benefit from relationships built within communities of practice.

Research has begun to document a number of powerful potential benefits from digital-media play, including positive social growth (more peer interaction around common interests), cognition (greater motivation to read and solve problems), and health (better understanding of the importance of healthy behaviors, improved self-care skills, more self-confidence and drive to carry out those skills).* In their recent review of learning and games, *Moving Learning Games Forward*, Klopfer, Osterweil, and Salen (2009) categorize different types of learning that are possible with games. For example, games can be effective at transmitting content

(from history to urban planning), at training on specific skills (from literacy to piloting planes), at developing systems thinking (how changing one element affects relationships as a whole), and at enabling the creation of artifacts (from videos to software code).
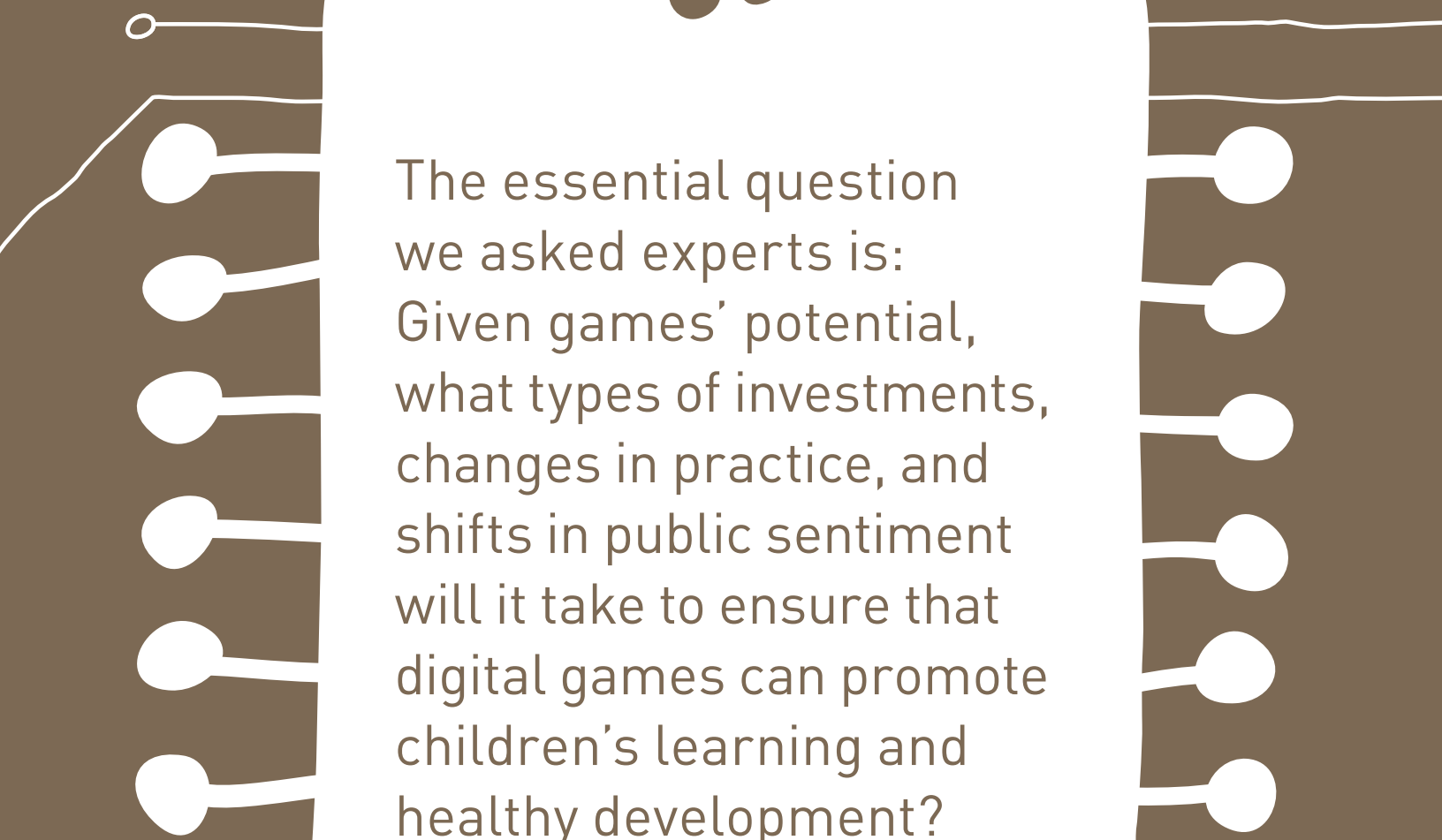
Even though evidence is not yet definitive, experts we consulted believe games hold great promise for learning. However, until we know more about how games work, and under which circumstances, we can not fully harness their benefits. With more than three-quarters of all American children playing computer and video games (ESA, 2009), we have a rare opportunity and a responsibility to build on the pockets of innovation outlined in this report, and to chart a new course to help create a healthy, engaged, and creative workforce for the 21st century.

*See p.52 for selected literature and Appendix C for a list of academic centers for game research.

innovating games for change: recommendations

The essential question we asked experts is: Given games' potential, what types of investments, changes in practice, and shifts in public sentiment will it take to ensure that digital games can promote children's learning and healthy development?

Our respondents agreed that American children's early engagement with games offers a critical opportunity to leverage these technologies for the public interest.

Our experts told us in chorus that in the digital age, the world inside our schools and health institutions has come to resemble the outside world less and less. Children in many schools, particularly in urban settings, lack motivation to meet expectations, are weakly engaged, and often drop out. Our conception of the nature of learning itself needs to fundamentally change. Sesame Workshop President and CEO Gary E. Knell remarked, "The question is: What is literacy and learning today? Is it memorizing a lot of facts, or is it having the capability to maneuver your way through data to find answers to questions that come up in your life?"

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Rob Lippincott, Senior Vice President of Education at PBS, predicts that if significant resources are not brought to bear on our learning challenges now, "we risk going from 30–35% high-school dropouts to 50–60% high-school dropouts [because] it's going to be boring." He believes the solution is in researching how to bridge the gulf between children's informal and formal learning environments. "There are so many 9-year-olds who have two or three screens in their personal control at home, and yet at school, we expect children to power down their devices and learn," Lippincott says.

Lack of engagement and motivation may also contribute to children's poor health habits. According to Ernie Medina, Co-Founder and CEO of XRtainment Zone, the problem is connecting

There are so many 9-year-olds who have two or three screens in their personal control at home, and yet at school, we expect children to power down their devices and learn.

knowledge to action: "People know the information. They already know what they need to do, 'I need to exercise more. I need to eat better. Eat more fruits and vegetables.' They're not doing it. [The breakthrough] that games for health can bring is in influencing behavior on a wide scale." Furthermore, Medina adds, games have the power to reach "the types of kids who typically are the hardest to motivate with traditional physical activity methods."

The allied fields of games-based learning and health fit into a larger movement that many observers refer to as "serious games." The efficacy and benefits of serious games are attracting notable popular attention. Civic leaders such as former Supreme Court Justice Sandra Day O'Connor are turning to the power of games to help children and youth learn, and to help engage the public in solving social problems. The military has been a leader in the use of games technology for more than a decade, deploying them in training and preparation of front-line soldiers and senior officers. Indeed, policymakers who wish to understand the potential impact of digital game technologies to transform practice can learn much from the significant financial and human capital investments made by the defense and security fields (see Appendix B for a select list of federally funded R&D digital-game projects).

As the experts point out, a fledgling field is producing new evidence of the effectiveness of well-designed games to advance children's learning and health. This much is clear:

• Digital games as a social phenomenon are here to stay.
• Kids already play them for fun — and for hours.
• Games have been shown to improve learning.
• Games have been shown to improve heath.

- Educational achievement and health outcomes are inextricably tied.
- More research and translation in practice is needed.

Furthermore, our inquiry uncovered dozens of exciting new game innovations that deserve wider scrutiny and possible adoption (see Appendix A). As things now stand, progress to integrate digital media such as games will continue haphazardly. The disconnect many children experience in their daily participation in learning and health institutions and their normal digital lives will grow. Alternatively, we can harness the energy and curiosity children bring to digital game play and channel it into focused learning that will help them grow into healthier, more productive citizens.

To accomplish this goal, we need to better understand the capabilities of high-quality games, and to develop strategies that help change behaviors and improve children's lives. It is time for government and the private sector to invest in understanding the potential of games in a much more focused way. The Joan Ganz Cooney Center recommends the following steps to jump-start a national action plan to address key learning and health challenges.

1. Expand R&D initiatives at federal and state levels

Most R&D funding for digital technologies that can be used for educational and health benefit is provided by the government — the Department of Defense (DoD), the Department of Education (DoE), the National Science Foundation (NSF), and the National Institutes of Health (NIH) (see Appendix B) — but it is unevenly distributed, highly fragmented, and lacks research priorities or mechanisms to foster intra-agency coordination and collaboration. We need better mechanisms to:
- Identify the learning gained through games and other digital media;
- Develop rigorous design, practice, and performance metrics; and
- Reach consensus on high-priority research goals.

> **!**
>
> ### Box 10: R&D challenges and opportunities
>
> In 2005, the Federation of American Scientists, Entertainment Software Association, and the National Science Foundation convened a National Summit on Educational Games to discuss ways to accelerate the development, commercialization, and deployment of new-generation games for learning. The resulting report summarized major topics that must be investigated in order to fully leverage the potential of games for learning and health. The areas that require more understanding include:
> - Features of challenges that are crucial for motivation and learning;
> - How stories/scenarios contribute to motivation and learning;
> - Impact of immersion and engagement on learner motivation;
> - Linking gaming features to goal orientation;
> - Features of game playing that contribute to development of higher-level thinking skills;
> - How games can be integrated in classrooms and formal learning environments to support learning goals.
>
> (Source: Federation of American Scientists, 2006)

Our experts suggested building on established priorities of organizations such as the NSF and the Federation of American Scientists, as well as creating new research collaborations across executive agencies. These efforts would enable a research network to identify gaps and determine how practices from one content domain could be transferred to others (see Box 10).

We recommend the following:

Research and development inventories
We need to know more precisely what is being done in the field. The federal government should conduct an inventory to determine what research is being funded and by which agencies. The data collection should be coordinated by the White House Office of Science and Technology Policy and Office of Management and Budget. The information

gathered would allow the identification of knowledge gaps and form the basis for a government-wide strategy to support digital media R&D. A similar effort should be initiated as the state level. We recommend that state-education agencies each conduct a funding and program "audit" to identify and categorize games and other digital-learning efforts currently being used in their jurisdictions. These reviews would determine how funding is being used and also catalog promising local, state, and global program innovations that could be showcased as models for scaling up.

State and regional summits

We recommend that governors, chief state school officers, and business groups such as the Business Roundtable and Committee for Economic Development jointly convene regional summits on the Future of Learning, particularly in areas with a concentration of high-tech industries and research universities (e.g., Silicon Valley, Los Angeles, Austin, and Boston/Cambridge). These summits should bring together research, industry, philanthropy, and practitioners to set priorities for research and development on digital media, and to suggest allocations of new investments by the government and private sources such as nonprofit organizations and market investors.

> **Box 11: A path to better collaboration**
>
> Providing a shared workspace for researchers and a distribution channel to end-users would make effective partnerships more practicable. The National Public Lightpath, a public media initiative supported by the Ford Foundation, leaders in public broadcasting, and other philanthropies, is proposing the creation of a high-speed fiber-optic network to connect the country's public-media and education communities. The Bay Area Video Coalition's Next Generation Digital Pathway Program is currently using the network to establish a virtual collaboration space for high-school students in San Francisco and Carenco High School in Lafayette, Louisiana, around 3-D gaming projects. A proposed national network would include a games channel that could produce games for learning, health, and civic participation. For more information, visit bavc.org.

Invest in infrastructure that supports R&D collaboration

Development of faster, cheaper multimedia sharing and delivery is needed in order for different disciplines and organizations to collaborate. One very promising initiative to establish such infrastructure is the National Public Lightpath, which proposes the creation of a national high-speed fiber-optic network (see Box 11). Such infrastructure could facilitate collaborations between researchers and organizations representing end-users to make games a practical tool for different settings.

2. Create innovative partnerships

The universe of digital learning is too large and too multidisciplinary to fit into old models of research and development. We need to establish innovative methods of funding and to provide incentives for creative networks of partners with different areas of expertise. One recent blueprint for modernizing research-agency activities, titled *Fostering Learning in a Networked World: The Cyberlearning Opportunity and Challenge*, developed by the NSF, outlines vital new directions for the field that could help focus related activities at other research agencies. Philanthropies also have an important role to play in this area.

The commercial game industry has shown little interest in learning games, a genre that lies outside its expertise in design, marketing, and distribution. Researchers such as Klopfer et al. (2009) believe that the most promising space for innovation in learning games is partnerships between academia and non-profits, funded by philanthropies and government agencies (see Appendix C for a list of academic research centers that focus on games research). The government can play an essential role by providing incentives to create partnerships, such as the public-private partnerships the Defense Department has forged with technology partners and game developers. As Pat Christen of HopeLab notes, the DoD "committed appreciable government resources to developing a quality product [virtual technology for soldiers] that's getting the desired outcomes." Other possible models are:

- Multi-stakeholder partnerships between game makers, foundation-supported nonprofits, and government funding, and
- "Double-bottom-line" companies that seek both social impact and return on capital investment.

> **!**
>
> **Box 12: A fruitful partnership**
>
> *Gamestar Mechanic*, a game about making games, resulted from a partnership funded by the MacArthur Foundation between the game company Gamelab, the Learning and Society Group at the University of Wisconsin-Madison, and the Institute of Play, a nonprofit dedicated to promoting gaming literacy. Gamelab developed and designed the game; the University of Wisconsin team evaluated the learning impacts associated with playing the game; and the Institute of Play is using the game as part of its curriculum in a new public school that is opening in New York City in September 2009.

We recommend the following:

Congress should:
- Support the newly established National Center for Research in Advanced Information and Digital Technologies. The center should focus significant resources on digital-game-based learning to advance children's learning and healthy development.
- Provide funding for agencies such as the NSF and NIH to establish interdisciplinary research centers for digital media and games at institutions of higher learning.

The White House should:
- Establish a Subcommittee on Digital Media and Learning within the National Science and Technology Council (NSTC) under the Committee on Technology to help ensure interagency coordination of digital media activities and related research on learning.

Federal research agencies should:
- The NIH and the U.S. Department of Education should fund fellowships and model training programs to create a critical mass of scientists who specialize in games; they should also establish funding streams that support innovative research by these investigators.
- The U.S. Department of Education's Institute of Education Sciences should fund exploration of alternative assessment models that integrate digital learning approaches to high-priority needs such as addressing literacy, science, and math achievement gaps.
- The Department of Health and Human Services, in collaboration with the NIH, should prepare a new meta-analysis of existing research on the positive impacts of games and other digital media on children's health and learning, leading to recommendations for further research. The research portfolio should include investigations on the potential of games for health promotion and disease prevention.
- Finally, one of the research entities, with support from philanthropic and policy leaders, should establish a national "best practices" initiative to disseminate effective uses of games technologies for education and healthy development.

Foundations, industry, and private investors should:
- Increase and leverage their investments in games and digital learning with strategies that support research, development, dissemination, and evaluation.
- Establish public-private partnerships and venture-funding models in partnership with key national and state-level agencies to allow the game-based learning sector to attract top talent and become sustainable.
- Health insurers should review the potential of health games as a prevention and treatment aid, as well as establish protocols for controlled trials to determine if selected games warrant additional support by health plans.
- Industry and investors should promote new "double bottom line" game-development entrepreneurs, who aim to achieve both profitability and positive social impact, as key innovation incubators. This can be accomplished by expanding public-private matching pools

and leveraging models such as the Small Business Innovation Research (SBIR) grant program. As an NSF task force recently advised: To "motivate participation across the private sector," we must "open up RFPs or agree to co-fund/cost share" the development of cyberlearning technologies with the private sector" (National Science Foundation, 2008).

3. Support adult guidance for children's digital activities

Children benefit most from well-designed educational media, including some of the games reviewed in this report, when they can play across formal and informal settings, and when adults help them and offer a context for the information or skills they are developing (Calvert & Wilson, 2009; Fisch, 2008). Too often, the bulk of the resources devoted to incorporating technology into education are expended on the hardware and software sides. More important than the technology itself is the human infrastructure needed to make new tools useful in learning. Teachers, parents, health professionals, and afterschool providers need to be trained to use, and understand the benefits and limitations of, digital games. This will entail professional development for teachers on how to integrate games into curriculum, new protocols for community health providers who wish to promote children's healthy habits, as well as outreach to parents that makes research understandable. As educators and parents begin to embrace games and digital media as part of a new learning equation that results in measurable new skills and content knowledge, schools will build more flexible instructional and assessment approaches to modernize their offerings and better engage the current generation.

We recommend that national, state, and community leaders commit to:

Building capacity through professional development and infrastructure investments
Teachers, health-care professionals, and youth leaders cannot teach with digital media they do not understand. Professional development is essential to the future of games-based learning. Training is not simply a matter of showing teachers how to use the devices; rather, it is crucial to teach them how to use the devices so that they can effectively integrate them into children's learning of academic subjects and in practicing healthful behaviors. To build teachers' capacity to utilize digital media meaningfully, we recommend greater investment in infrastructure that supports rich teacher training experiences and other professional development around digital media and learning.

A Digital Teacher Corps
To build professional capacity, we recommend the creation of a "digital teacher corps," modeled on initiatives such as Teach for America. First proposed by James Paul Gee, the corps would begin work in the lowest-performing elementary schools and in afterschool settings throughout the country. The goal will be to enable educators to help students learn to transform information into knowledge used for discovery and problem-solving. Through the corps, teachers and youth-development specialists would work with a range of digital media, including games and mobile technologies, to engage students in an environment that teaches skills, content, and new ways of thinking. A first line of attack, Gee has argued, should be in reversing the tragic but preventable "fourth grade reading slump" with more imaginative and sustained digital innovation.

Stimulating new community child health approaches
Community health centers and school-linked health educators are essential front-line personnel in developing lifelong healthy habits for at-risk children. These groups should receive seed funding to establish digital learning centers that deploy cost-effective behavioral-change games and new technologies that help young children and their families to address obesity and other related long-term health issues. The games should focus on nutrition and weight management, exercise, self-care, and overall health-risk appraisal. Further, to help address the growing obesity problem, K–12 schools and community health centers should form partnerships to incorporate exergaming into students' daily activities in school and out.

Developing models to engage communities around digital media and learning

A number of promising afterschool models are already helping children from underserved communities become "tech savvy" and are developing innovative approaches to parent training that includes digital content such as games that can be used across settings. These models include the Intel-sponsored Computer Clubhouses, the Boys & Girls Club of America's Club Tech, and locally-based youth-leadership programs such as Global Kids, One Economy, and Computers for Youth. National efforts to bridge school, home, and community uses of game technologies should learn from, improve upon, and scale-up these models.

4. Modernize public media

Led by producers such as Sesame Workshop, WGBH, WNET, and PBS KIDS, educational television media for young children have a strong track record, indicating that under the right conditions, skills such as basic reading and math, as well as more complex social, health, and problem-solving skills, can be enhanced for all children, especially those from underserved communities. It is now time for these television-based efforts to be modernized to accommodate the needs and interests of children living in a digital age.

A first step would be to support ongoing efforts to reinvent the Ready to Learn program financed by Congress and led by the U.S. Department of Education and CPB. Ready to Learn currently reaches millions of low-income children in preschool and the primary grades with quality television fare but has only recently invested resources in extending learning on new platforms, and through wide distribution in schools and community settings. Research on experimental aspects of the current Ready to Learn program shows that school-based interventions utilizing games and other curriculum resources can significantly improve literacy skills for underserved children (Revelle, 2009). This promising line of study and experimentation on new platforms should be expanded to explore how early learning and health behaviors might be advanced by a new approach to curriculum-based game play within

educational programs that link home, school, and community institutions such as libraries.

We recommend adding significant funding to the production and distribution of Ready to Learn so the program can expand to include:

- Wider experimentation with new formats such as games and mobile learning to teach children both traditional and new literacy skills that include knowledge of science, technology, and math, as well as the development of healthy habits.
- Creative business models and incentives to ensure the wide distribution of media to schools and other learning centers. Our nation must find ways to leverage the hundreds of millions of dollars of previous public investment in educational programming for children. A tremendous archive of materials can now be used for further public benefit on new platforms.
- Investment in the National Public Lightpath initiative to create a high-speed fiber-optic network to connect the country's public media and education communities, including a games channel.

5. Initiate a public dialogue about digital media and games

If scalable models and compelling research become available in the decade ahead, the potential of games to transform learning and healthy development will become increasingly apparent. However, to integrate these media into daily practice, public concerns must be addressed. The public dialogue surrounding games and children has often been framed by an understandable focus on violence, sexual content, inappropriate language, and safety. As games have extended their reach to new audiences, they have gained more positive support in the public discourse. Proponents of games for children's education and health, however, suggest the need for a new effort to engage the public on the potential benefits of digital media (see Box 13).

The very notion of enlisting games to serve the national interest is "still quite controversial," observes Katie Salen, Executive Director of the

Box 13: A new day for learning

Funded by the MacArthur Foundation's Digital Media and Learning initiative, which is exploring the ways in which interactive media are transforming how children and youth learn, participate in civil society, and relate to one another, Common Sense Media has developed a new public-engagement campaign. Common Sense has created a comprehensive web portal, conducted national surveys, assigned community ratings of popular media products for children, and conducted "town hall meetings" about children's and digital media. These efforts are intended to translate new research on the participation of children in digital media, as well as explore the education, health, and ethical issues that these media raise in civil society. Their efforts, and other groups' commitments to research and public dissemination, signal an important step, but more investment in communication between researchers, game developers, parents, and educators is needed to inform the public dialogue.

potential and limitations of digital media. Funders should encourage researchers to partner with parent, educator, and consumer advocacy groups to make their research more accessible and practical for application. Engagement efforts might include: the expansion of media literacy curricula in schools; the creation of highly accessible parent guides to digital media by magazines and newspapers; and "town hall meetings" and "summits" on the constructive role that digital media play in children's learning and our nation's future.

In addition, what children need to know and be able to do in a digital age goes well beyond "The Three Rs." Leaders in education and the business community must stimulate a continuing dialogue on 21st-century skills, including creativity, problem-solving, and cultural knowledge that will help ensure our nation's global competitiveness. The Partnership for 21st Century Skills, which now works in over a dozen states, should pioneer the use of digital media, including games, as part of its research and public-engagement efforts to define a new model for learning.

Institute of Play. "A lot of people have assumptions about what video games are good for and not good for, [and] questions around how young people are spending their time," she says. Though experts have found that games have significant potential to boost children's learning and healthy development, parents and teachers are not yet convinced. A 2008 study by Common Sense Media and the Joan Ganz Cooney Center at Sesame Workshop in collaboration with Insight Research Group found that parents and teachers were skeptical about the educational value of games (see Box 14). The study found that teachers see the Internet, computer programs, and CD-ROMs as having more educational potential than video games.

We recommend national, state, and community leaders commit to:

Public engagement efforts linked to research on "21st-century skills"
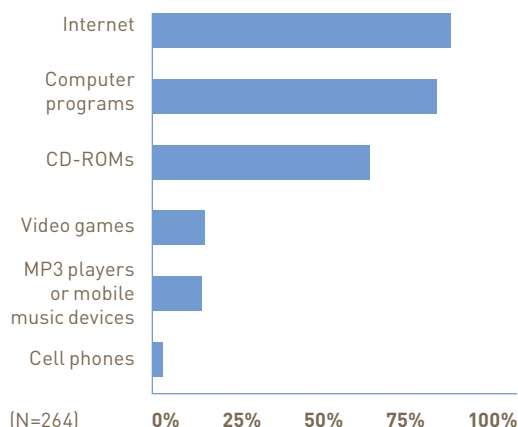
Translating research findings to broader audiences will be critical in educating the public about the

Box 14: Parents and teachers rate digital media's potential as an educational tool

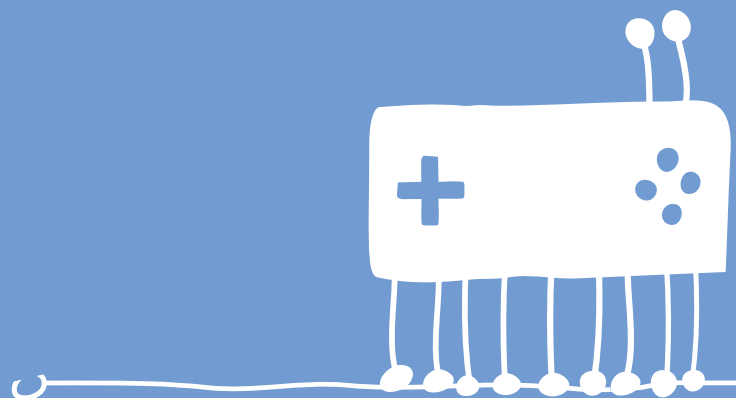*How much potential do you feel the following kinds of digital media have as educational tools?*

(N=264)

(Source: Joan Ganz Cooney Center & Common Sense Media, 2008)

conclusion: can digital play be a game changer?

Dr. James Comer of the Yale Child Study Center noted nearly three decades ago: "Playing games helps children learn to live by rules and establish the delicate balance between competition and cooperation." He added that game play helps children "learn to manage the warmth of winning and the hurt of losing ... to believe that there will be another chance to win the next time." Games offer vital aid for such growth only if a strong web of adult guidance supports children beginning in the early years (Comer, 1980).

As younger and younger children have made digital play a preferred mode of social expression, their needs for engagement with caring, dependable adults have not changed.

However, the challenges and opportunities that shape children's prospects today are perhaps more complex than ever before. Unfortunately, American schools haven't changed much in design since the industrial age, and are failing to accommodate children's new styles of learning and play. As usual, adults have not yet caught up to the kids.

The growing phenomenon of digital game play documented in this report cannot be dismissed. The debate in the coming decade should, of course, focus on children's safety first, and on critical issues such as the quality of early education, teaching, and health care. But this report suggests a new element in our national dialogue about children's well-being. A different framework would carefully marshal evidence and explore how, not whether, digital media might best be used. Such a welcome departure from current practices could, simply put, be a real game changer.

appendix a: health games, learning games, and research projects

Below is a list of learning and health games noted in several of the interviews conducted for this paper. Other games discovered in the literature review process, including some identified in the Cooney Center's *D is for Digital* report and The Education Arcade's *Moving Learning Games Forward* report, are also included. These games illustrate promising ways that electronic learning and health games are being utilized to advance children's development. In addition, the list reveals how new this emergent field of learning and health games is and underscores the need for a better-coordinated, multi-sector R&D effort to more fully realize the potential of the medium.

Project	Description
American Dental Association Games & Puzzles	The American Dental Association website has online games and puzzles to help children become more familiar with dental-related vocabulary and learn habits to maintain strong, healthy teeth. In *Match-A-Tooth*, players are required to match two pictures. When they make a perfect match, the site gives dental advice such as "Floss your teeth everyday" or "Visit your doctor regularly." In *Dental Space Odyssey*, the player has to control a spaceship and avoid objects such as candy or other types of junk food. **Collaborator** American Dental Association (www.ada.org/public/games/games.asp)
The Asthma Files	*The Asthma Files* is an interactive, educational computer program designed to teach children about asthma, its triggers, and management of the condition. **Collaborators** A multidisciplinary team involving medical, nursing, psychology, and multimedia workers, in conjunction with the National Asthma Campaign in the U.K. (theasthmafiles.wikispaces.com)
Ayiti: the Cost of Life	*Ayiti: the Cost of Life* is a strategy game that asks, "What is it like to live in poverty, struggling every day to stay healthy, keep out of debt, and get educated?" Set in rural Haiti, players must manage the lives of a family of five, struggling with minimal resources to achieve a stable, safe, and healthy environment. The game is very difficult but provides win states and suggests that no problem is unsolvable. **Collaborators** New York's Global Kids program, developers at Gamelab, Microsoft Corporation U.S. Partners in Learning, and students from South Shore High School in Brooklyn, NY (www.gamelab.com/game/ayiti)

Project	Description
Bronkie the Bronchiasaurus	This asthma self-management game is a side-scrolling adventure challenge on the Super Nintendo platform for children ages 7 and older, As dust clouds settle over fictional San Saurian, dinosaur friends Bronkie and Trakie must find and assemble all the pieces of the wind machine before it's too late. While searching, they manage their asthma and fend off evil dinosaur thugs who are guarding the machine pieces. Game play also involves answering multiple-choice questions on topics including the respiratory system, basic asthma self-management, identifying and avoiding triggers, recognizing and responding to early warning signs, what to do in asthma emergencies, the purpose of asthma medications, the importance of following a sick-day plan, asthma and strenuous exercise, and how to handle common social situations. **Collaborator** WaveQuest (www.en.wikipedia.org/wiki/Bronkie_the_Bronchiasaurus)
Color Me Hungry	*Sesame Street*'s *Color Me Hungry* combines game play with a campaign called "Healthy Habits for Life" to help children make healthy food choices. Available on the *Sesame Street* website, the game helps preschoolers learn the importance of "eating your colors" by choosing fruits and vegetables. **Collaborators** Sesame Workshop, PBS KIDS (www.pbskids.org/sesame/#/games)
Dance Dance Revolution	This exergame, developed in the arcades of Japan more than a decade ago, requires players to dance in progressively more complicated and strenuous patterns in time with electronic dance music. It is now being incorporated into gym classes in schools throughout the country. A study by the Mayo Clinic in Rochester, Minnesota, found that children playing *Dance Dance Revolution* expended significantly more physical energy than children watching television and playing traditional video games. West Virginia has sponsored its own study and has taken the lead in deploying the game to schools throughout its school districts. **Collaborators** DDR Game, Konami, West Virginia University, West Virginia's Department of Education, Mountain State Blue Cross and Blue Shield (www.ddrgame.com)
dbaza's Diabetes Education for Kids	*dbaza's Diabetes Education for Kids* is an interactive CD-ROM game that teaches kids about the basics of diabetes care. The game begins with with blood-glucose testing, then moves on to hypoglycemia and hyperglycemia, insulin injections, food choices, carbohydrate counting, and exercise. The full program takes several hours to complete, but it can be paused at any time and picked up again upon return. The game reinforces its educational messages often, and asks kids to make a virtual book in which they explain the lesson they've just learned. For the Windows platform. **Collaborator** dbaza, inc. (www.mobygames.com/game/dbazas-diabetes-education-for-kids)

Project	Description
EyeToy Kinetic	This exergame sits on a television and plugs into the PlayStation 2 console. It registers the motion of the player's body, transforming it instantly to onscreen action, so that the player's image becomes part of the game. **Collaborators** Sony Computer Entertainment Europe, Eye Toy Kinetics, PS2, Nike Motion Works (www.eyetoykinetic.com)
FATWORLD	*FATWORLD* is a video game about the politics of nutrition. It explores the connections between obesity, nutrition, and socioeconomics in the contemporary U.S. The game's goal is not to tell people what to eat or how to exercise, but to demonstrate the complex, interwoven relationships between nutrition and factors like budgets, the physical world, subsidies, and regulations. Players can choose starting weights and health conditions, including predispositions towards ailments like diabetes, heart disease, or food allergies. Players have to construct menus and recipes, decide what to eat and what to avoid, exercise (or not), and run a restaurant to serve the members of their community. **Collaborators** Persuasive Games, PBS' Independent Lens, Independent Television Service (ITVS), Electric Shadows Project, CPB (www.fatworld.org)
Fix Frank	The American Diabetes Association website contains a collection of online games to help children learn about nutrition and the human body. For example, in *Fix Frank*, the player must drag and drop organs inside "Frank" — a green Frankenstein character. Selecting an organ brings up information about what it does and where it goes. Once all the organs are successfully placed inside Frank, information about insulin, the pancreas, and food absorption is displayed. Other titles include *Build a Healthy Kid, Build a Healthy Plate, Food Fight*, and *Food Safari*. **Collaborator** American Diabetes Association (www.diabetes.org/youthzone/fun-games.jsp)
Food Force	Players distribute food in a famine-affected country to help it recover and become self-sufficient again. On this mission, they learn about hunger in the real world and what is being done to prevent it. The setting is the fictional island of Sheylan, which is suffering from both drought and civil war. There are six missions, and each can be played through in under an hour. High scores can be uploaded online for worldwide comparison with other players. **Collaborators** United Nations World Food Program, Playerthree, and Deepend (ff.fighthunger.org/index.php/game/)
Gamestar Mechanic	*Gamestar Mechanic* engages students in multi-modal thinking about technology, social, artistic, and communications concerns. The game teaches players about game design by asking them to develop hypotheses for their designs, and implement and test those designs while simultaneously describing and defending their designs to their teammates; in a sense, players become "socio-technical engineers." **Collaborators** Institute of Play, University of Wisconsin-Madison, Gamelab (www.gamestarmechanic.com)

Project	Description
Germinator	*Germinator* teaches children about germs and the biological rationale behind good-hygiene habits. A player assumes the role of a germ trying to invade the body's immune system and must avoid earwax, mucus, tears, and soap to reach entry into the body. Once in the bloodstream, players try to infect cells while avoiding detection by B cells and attack by macrophages and killer T cells. **Collaborators** PBS KIDS, National Science Foundation (pbskids.org/fetch/games/germinator/index.html)
Globaloria	Globaloria is a first-of-its-kind social network for learning how to master game creation in Flash programming, with industry-standard, social media technology and Web2.0 tools and applications such as MediaWiki software, Blogging, Google tools, WebEx video conferencing, among others. Students work on their web-games individually and in teams, within an open-source, activity-driven, transparent, networked learning community, and focus their games on educational and social issues such as mathematics, science, health, civics, environment, poverty, or peace. **Collaborators** Globaloria was created by the World Wide Workshop Foundation. Collaborators include the Governor of West Virginia, West Virginia Department of Education, Claude Worthington Benedum Foundation, John S. and James L. Knight Foundation, West Virginia Center for Professional Development, Verizon, The Caperton Fund, AMD Foundation, Southwest Key Programs, Schlumberger-SEED, HBO, 21CF, Rethink, and Cisco. (www.Globaloria.org; www.WorldWideWorkshop.org)
Glucoboy	*Glucoboy* is an advanced blood-glucose meter that can be used with the Nintendo Game Boy® Advance System or DS to form a network that rewards testing compliance and good health management. *Glucoboy* assists patients and support networks, helping them work together to provide a high level of care, compassion, and compliance. **Collaborators** Guidance Interactive Healthcare, Nintendo (www.glucoboy.com)
The Horsepower Challenge	This activity-powered game is designed to encourage school-age children across America to become more physically active. The most recent launch, named The American Horsepower Challenge, engages 20 members of Congress and 2,000 fifth- and sixth-graders from across the country in a web-based game where each student creates a horse avatar and powers it by taking steps in the real world. **Collaborator** Humana Games for Health (www.humanagames.com)

Project	Description
Hungry Red Planet	This computer game sends children on a space mission to colonize Mars. They accomplish this by establishing healthy, food-producing settlements. **Collaborator** Health Media Lab (www.commonsensemedia.org/game-reviews/Hungry-Red-Planet.html)
IMPACT	*IMPACT* is an interactive CD-ROM game developed by obesity researchers as a tool to help offset the rising incidence of obesity in America. Through eight episodes, students learn the benefits of increasing their physical-activity levels and making other lifestyle changes. Designed for the classroom, computer lab, or as take-home assignments, *IMPACT* is entirely self-paced and suitable for children age 9 and older. **Collaborator** ToucanEd (www.toucaned.com/Products/GeneralEd/Impact.html)
The Incredible Adventures of the Amazing Food Detective	An interactive bilingual CD-ROM that provides players with hands-on activities and games to reinforce key health messages. Children join forces with a detective to solve eight mysteries around why some kids are unhealthy. By playing the game, kids learn about healthful foods and exercise habits. The target audience is 9-to-10-year-olds, but most of the mini-games can be enjoyed by children as young as 6. **Collaborator** Kaiser Permanente (www.amazingfooddetective.com)
Lure of the Labyrinth	Designed for middle-school students, the game's primary goal is to enhance pre-algebra math learning, with a secondary goal of improving literacy. *Lure of the Labyrinth* is a long-form puzzle adventure played over many sessions, with a persistent narrative that evolves over time. Players must navigate complex mathematical spaces and solve puzzles that embody the big ideas of mathematics. Playing on teams, students have incentives to share their ideas about puzzle-solving through an in-game message board, thereby generating the kind of literacy activities usually reserved for game FAQs and interest groups. **Collaborators** The Learning Games to Go (LG2G) project, funded by a Star Schools grant from the U.S. Department of Education, spearheaded by Maryland Public Television (MPT) (www.making-history.com/hq)
Making History: The Calm and the Storm	This multiplayer, turn-based strategy game teaches history, international relations, and political science to high-school and college students by focusing on 20 years surrounding World War II. Students take on the roles of national leaders, and each student has a unique set of goals, leading to temporary alliances on certain issues. The game features four areas of policy: domestic, diplomatic, economic, and military; each scenario can be played in about 40 minutes. The original, self-published game was designed for use in classrooms. **Collaborators** Muzzy Lane Software. An updated version of the game was published by Strategy First for an entertainment market and sold through traditional retail channels. (www.making-history.com/hq)

Project	Description
Our Courts	*Our Courts* teaches young people about the U.S. justice system and the role of the judiciary in the three-branch system of the U.S. government. The free online game will be unveiled in two phases beginning in 2009: The first will be an online civics program aimed at grades 7–9, while the second will be a more gaming-driven offering designed to engage young people in their free time. **Collaborators** Retired U.S. Supreme Court Justice Sandra Day O'Connor, Arizona State University, Cabengo LLC, EDC's Center for Children & Technology, E-line Ventures, Filament Games, Georgetown Law, Studio Mobile (www.ourcourts.org)
Packy & Marlon	*Packy & Marlon* is a side-scrolling adventure video game for the Super Nintendo platform popular in the early 1990s that uses experiential learning to improve self-management among diabetic children and adolescents. Players take on the role of a character that has diabetes; they manage their character's blood-glucose monitoring, insulin use, and food selections for four simulated days while the character tries to save a diabetes summer camp from marauding rats and mice. Keeping their character's blood glucose within the normal range, through appropriate insulin use and food choices, helps players win the game. A six-month clinical trial with *Packy & Marlon* found that diabetic children and adolescents who were randomly assigned to take home the diabetes game reduced their diabetes-related urgent-care and emergency-room visits by 77%, compared to no change in the group randomly assigned to take home an entertainment video game that had no health content (Brown et al., 1997; Lieberman, 2001). **Collaborator** WaveQuest (www.en.wikipedia.org/wiki/Packy_and_Marlon)
Pajama Sam 3: You Are What You Eat From Your Head to Your Feet	The third game in the *Pajama Sam* series, part of the popular Junior Adventure titles designed for children ages 3–8. Players are invited to learn healthful food awareness, listening, and decision-making skills in the game. Along their journey, they interact with more than 20 different comic-style characters. For the Macintosh, Windows, and PlayStation platforms. **Collaborator** Humongous Entertainment, Inc. (www.mobygames.com/game/pajama-sam-3-you-are-what-you-eat-from-your-head-to-your-feet)
Palmagotchi	The mobile game *Palmagotchi* combines virtual pets (such as the popular Tama-gotchi toy) and the evolutionary story of Darwin's finches in the Galapagos Islands. Players maintain families of birds by monitoring, feeding, and mating them. The game, designed to be school-friendly, is paced to require interactions every three to four hours, so as not to disrupt classes, but also to create a sense that players must be vigilant to keep their organisms alive and well. This game can be played casually, anytime and anywhere. **Collaborator** MIT Scheller Teacher Education Program (education.mit.edu/drupal/myworld)

Project	Description
Participation Nation	*Participation Nation* is a multi-platform game designed to help middle-school and high-school students understand the contemporary relevance of the Constitution and the Bill of Rights. Players can act as the "Forces of Change" or the "Status Quo" in a series of debates over the constitutional issues that shaped the country. These debates take the form of an online collectible card game, which is supported by a set of integrated media components including a comic book, webisodes, a social network, and a database of primary sources. **Collaborators** Corporation for Public Broadcasting, Los Angeles' KCET, video game company Activision Blizzard, Inc., the University of Southern California Game Innovation Lab, the Center for Civic Education in Los Angeles, and the National Center for Teaching History in Schools (interactive.usc.edu/projects/games/20090327-participat.php)
Peacemaker	Inspired by real events in the Israeli-Palestinian conflict, this video and computer game challenges the player to be a leader, either the Israeli Prime Minister or the Palestinian President, and bring peace to the region before the current term in office ends. Using real news footage and images, it asks how the player would react to events in the Middle East. *Peacemaker* has three levels of difficulty: calm, tense, and violent. **Collaborators** ImpactGames, Carnegie Mellon University in Pittsburgh (www.peacemakergame.com)
Playnormous	*Playnormous* is a free online community where children and their parents can learn about health in a fun, interactive way. *Playnormous* games such as *Food Fury*, *Lunch Crunch*, and *Brain Gain* are designed for everyone but are specifically conceptualized for children ages 6 to 15 and their parents. **Collaborator** Playnormous, Humana Games for Health, Children's Nutrition Research Center at Baylor College of Medicine, and the Games for Wellness Project at The University of Texas School of Health Information (www.playnormous.com)
Possible Worlds	EDC's Center for Children and Technology in New York and EDC's Center for Science Education in Boston will develop a curriculum for grade 7 science students, with four game modules (for the Nintendo DS) that will supplement traditional instruction. The curriculum will offer teachers and students in-depth explorations of scientific problems, countering students' scientific misconceptions, reading difficulties, and lack of motivation that often complicate hamper science teaching. **Collaborators** EDC's Center for Children and Technology, EDC's Center for Science Education, 1st Playable Productions (possibleworlds.edc.org)

Project	Description
Racing Academy	*Racing Academy* offers students accurate, real-time, virtual models of race cars. Students build, maintain, and race their vehicles, monitoring and analyzing their cars' performances via data from various telemetry outputs. By participating in virtual communities of practice, students make complex decisions collaboratively, manipulating more than 1,000 parameters on their vehicles. **Collaborators** FutureLab in the United Kingdom, in combination with independent developer Lateral Visions, the U.K. Higher and Further Education Joint Information Services Council, and the Department of Psychology at the University of Bath (www.futurelab.org.uk/projects/racing-academy)
Re-Mission	*Re-Mission* is a video game designed to encourage adolescent and young-adult cancer patients to take an active role in fighting their cancer by targeting key behavioral and psychological outcomes. In the game, players control a microscopic robot named Roxxi as she enters the bodies of cancer patients to blast away malignant cancer cells to stop them from spreading. Players must also monitor the side effects of cancer treatment, keep fevers and infections in check, and manage various other effects of cancer and treatments. Game missions and weapons (such as a "chemoblaster") correlate directly to various aspects of cancer and cancer treatment. A randomized controlled study of *Re-Mission* showed that playing *Re-Mission* improves treatment adherence and significantly increases cancer knowledge and self-efficacy in young cancer patients (Kato et al., 2008; Tate et al., 2009). **Collaborators** HopeLab, Realtime Associates, Inc., Treanor Brothers Animation, TRI (www.re-mission.net)
RightWay Café	*RightWay Café* promotes a healthy diet for young adults. Interactive tailoring, role-playing, elements of fun, and narrative are used to influence and change behavior. A randomized controlled evaluation study with pre-test, post-test, and follow-up design demonstrated that this game was effective in teaching nutrition and weight-management knowledge and increasing players' self-efficacy and perceived benefits of healthy eating, as well as their intention to be on a healthy diet. Participants in the game-playing group had greater self-efficacy than participants in the control group after one month. (Peng, 2009). **Collaborator** Michigan State University
River City	In *River City*, middle-school students work in teams as scientists as they step back into the 19th century to battle a mysterious epidemic. This game tests the strengths and limits of an emerging learning technology: MUVE, or multi-user virtual environments. **Collaborator** The National Science Foundation, Smithsonian's National Museum of American History—Division of Information Technology and Society, Arizona State University's Educational Technology Graduate Program, Harvard University's Graduate School of Education, and 100 teachers with over 5,000 students in 12 states (muve.gse.harvard.edu/rivercityproject/)

Project	Description
Slinky Ball	*Slinky Ball* is a computer-based physics simulation for middle-school students. In 2008, 91 sixth-graders from two schools in New York City were randomly assigned to play one of two computer games: *Slinky Ball* (treatment condition) or *Ayiti: The Cost of Life* (control condition). Students played their assigned game for two class periods (50 minutes total), and their learning was assessed through their written answers to a survey after playing the game; teacher and researcher observations; and differences between pre- and post-test scores on a science exam. Students who played *Slinky Ball* were significantly more likely than students who played *Ayiti* to improve in problem-solving. **Collaborators** Hidden Agenda Games, Computers for Youth (www.hagames.com/slinkyball.aspx)
Sneeze	*Sneeze* is a free-to-play browser-based game for people of all ages that teaches how infections can spread when people sneeze. A player is a virus who, to survive, must make his or her human host sneeze and infect other humans. To reach the next round, the player virus must infect a target percentage of the population. **Collaborators** The U.K.'s Channel 4 Education, in association with the Wellcome Trust (www.routesgame.com/games/?challengeId=2)
Squire's Quest	In *Squire's Quest*, each young player starts as a squire training to become a knight. Knights help to protect an imaginary kingdom, called "Five-A-Lot," from invaders bent on destroying its fruits and vegetables. As squires earn points toward various levels of knighthood, they learn about fruits, fruit juices, and vegetables. The video game is part of a series of ten 25-minute-long classroom sessions in which kids make healthy virtual recipes, as well as set personal goals for using these recipes at home. **Collaborators** Baylor College of Medicine, Children's Nutrition Research Center in Houston, USDA/ARS, Texas Children's Hospital (www.bcm.edu/cnrc/consumer/archives/videogames.htm)
Urban Science	Players learn about ecology, develop self-confidence and presentation skills, and start to see the world through the eyes of a problem-solving urban planner. **Collaborators** The Epistemic Games Research Group, housed within the Educational Psychology Department and the Wisconsin Center for Education Research at the School of Education, University of Wisconsin-Madison (www.epistemicgames.org/eg/?cat=14)
Watch, Discover, Think, and Act	*Watch, Discover, Think, and Act* is an asthma-self-management computer program aimed at inner-city children. The intervention focuses on teaching in two categories: asthma-specific behaviors such as taking preventive medication, and self-regulatory processes such as monitoring symptoms and solving asthma-related problems. **Collaborators** Center for Health Promotion Research and Development, University of Texas Health Science Center at Houston

Project	Description
Zoo Scene Investigators	*Zoo Scene Investigators* is played on location at Ohio's Columbus Zoo, where middle-school students use location-aware handheld computers to investigate a fictitious crime. Players physically walk around the zoo in teams to collect the virtual information provided on their handhelds to apprehend the criminal, learning about particular animals and the impact of the illegal wildlife trade. *Zoo Scene Investigators* demonstrates the integration of games into informal learning environments such as museums, zoos, and aquaria, as well as the integration of relevant, real-world experiences with the virtual worlds of games. **Collaborators** The Columbus Zoo and Aquarium, Columbus, Ohio, and the MIT Scheller Teacher Education Program (www.columbuszoo.org/education/schools_and_teachers/plan_your_field_trip/programs/self_guided_programs/zoosceneinvestigators.aspx)

appendix b: federally funded game research and development

Federal agencies are supporting video game research and development. The biggest investor is the U.S. Department of Defense, which, all told, spends roughly $6 billion annually on various virtual and simulated training programs and equipment (Vargas, 2005).

No comprehensive list of federally funded projects now exists, so to contribute to the development of a coherent R&D plan, we began to compile one. We asked our interviewees to name federally funded game projects they were aware of, and we searched federal agency websites. We also searched the Internet for the tag words "video games" and the names of federal agencies. This list is far from exhaustive. A thorough inventory of all federally funded games research is needed to ascertain the full extent of the federal government's role in the R&D of video games.

Department of Defense			
Project	**Focus**	**Description**	**Funding level**
America's Army	Training, recruitment	A training and combat video game available free to potential recruits either online or at recruiting stations.	$6M–8M
Virtual Kuwait	Training	This virtual environment for warfare-simulation training is used to train personnel to anticipate and defend against an attack on the U.S. Embassy in Kuwait City.	$3.5M
Virtual Iraq	Therapy	Virtual-therapy research at six sites around the country resulted in the development of this video game, used to help soldiers suffering from post-traumatic stress disorder in Iraq. The game is designed to elicit painful memories from the soldiers but in a controlled setting, permitting them to speak with therapists.	$5M

Department of Education			
Project	**Focus**	**Description**	**Funding level**
Possible Worlds	Science literacy	EDC's Center for Children and Technology and Center for Science Education will develop and evaluate a series of middle-school game modules to be used with the Nintendo DS console.	$9.2M
McLarin's Adventures	STEM	This online survivor game seeks to build science, tech, engineering, and math learning for middle- and high-school students and was conceived by the University of Oklahoma's K20 Center.	$4.2M from a Star Schools grant; NSF is providing ongoing support
Augmented Reality	STEM	With funding from a DoE Star Schools Program grant, researchers at Harvard, University of Wisconsin-Madison, and MIT developed a series of "augmented reality" games designed to teach math and science literacy skills to middle-school students. The games use GPS technology to correlate students' real-world location to their virtual location in the game's digital world.	$1.5M

National Science Foundation			
Project	**Focus**	**Description**	**Funding level**
CyGaMEs (Cyberlearning through Game-based Metaphor Enhanced Learning Objects)	Science	Funded by NSF through a grant to the Center for Educational Technologies (CET) at Wheeling Jesuit University. Part of the grant is to continue development of *Selene: A Lunar Construction GaME*, in which players learn how Earth's moon was formed as they create their own moon and then pepper it with impact craters and flood it with lava flows.	$2M from NSF; additional support from NASA
UC Irvine Study on *World of Warcraft*	Research	NSF funded University of California at Irvine to study the differences in how gamers from the U.S. and China play *World of Warcraft*, a popular online video game that allows opponents to do battle on the planet Azeroth.	$100,000
GRADUATE (Games Requiring Advanced Developmental Understanding and Achievement in Technological Endeavors)	Training, digital literacy	Members of North Carolina State's College of Education have teamed up with the Kenan Institute for Engineering, Technology and Science and international gaming company Virtual Heroes, Inc. to develop easy-to-use game creation tools that will assist students in completing North Carolina's new graduation project requirement.	$1.5M over three years
WolfQuest	Environmental learning, ecology	*WolfQuest*, a computer game developed and hosted by the Minnesota Zoo, engages high-school students in role-playing a wolf to learn about wolf behavior and ecology.	Over $500,000
River City	Scientific inquiry, 21st-century skills	Harvard University received support to create an interactive computer simulation for middle-grades science students to learn scientific inquiry and 21st-century skills, with content from National Science Education Standards and National Educational Technology Standards. Additional support from NSF is being sought to rebuild River City in a modern authoring system to make it cross-platform and to make it available under a free license.	Three rounds of funding for a total of approx $3.6M

appendix c: academic centers for game research

Center	Description
The Academic Advanced Distributed Learning Co-Lab	The University of Wisconsin-Madison Department of Educational Psychology has teamed up with the UW System's Academic Advanced Distributed Learning Co-Lab to create new worlds in which people can learn by exploring and doing. Established in January 2000, the lab specializes in competency-based modules for worldwide learning that can be utilized anytime and anywhere — in the classroom, in the field, and online. (wistechnology.com/articles/958)
EDC's Center for Children and Technology	EDC's Center for Children and Technology (CCT) serves as a National R&D Center on Instructional Technology, investigating how video games can be used in middle-school classrooms. In collaboration with EDC's Center for Science Education, CCT will develop and pilot-test a series of game modules — to be used with the very popular Nintendo DS — that capitalizes on youth's fascination with electronic games. The new R&D center and its work are funded by the U.S. Department of Education, Institute of Education Sciences. (cct.edc.org)
The Education Arcade	The Education Arcade (TEA), based at MIT, explores games that promote learning through authentic and engaging play. TEA's research and development projects focus both on the learning that occurs naturally in popular commercial games and on the design of games that more vigorously address the educational needs of players. Its mission is to demonstrate the social, cultural, and educational potentials of video games by initiating new game-development projects, coordinating interdisciplinary research efforts, and informing public conversations about the broader and sometimes unexpected uses of this emerging art form in education. (www.educationarcade.org/about)
The Epistemic Games Research Group	The Epistemic Games Research Group is housed within the Educational Psychology Department and the Wisconsin Center for Education Research at the School of Education, University of Wisconsin-Madison. It comprises researchers, educators, and game designers at the University of Wisconsin-Madison. (epistemicgames.org)

Center	Description
Games for Learning Institute	The Games for Learning Institute (G4LI) is a joint research endeavor of Microsoft Research, New York University, and a consortium of universities. The partners include Columbia University, the City University of New York (CUNY), Dartmouth College, Parsons The New School for Design, Polytechnic Institute of NYU, the Rochester Institute of Technology, and Teachers College. The G4LI will identify which qualities of computer games engage students and develop relevant, personalized teaching strategies that can be applied to the learning process. With a $1.5 million grant from Microsoft and $3 million in funding total, the first three years of the G4LI's research will focus on evaluating computer games as potential learning tools for science, technology, engineering, and mathematics (STEM) subjects at the middle-school years (grades 6–8). The institute will work with a range of student populations yet focus on underrepresented middle-school students, such as girls and minorities. (g4li.nyu.edu)
Health Games Research	Health Games Research is an $8.25 million national program of the Robert Wood Johnson Foundation (RWJF) that supports outstanding research to enhance the quality and impact of interactive games used to improve health. The goal of the program is to advance the innovation, design, and effectiveness of health games and game technologies so that they help people improve their health-related behaviors and, as a result, achieve significantly better health outcomes. Program funding comes from RWJF's Pioneer Portfolio, which supports innovative ideas and projects that may lead to breakthroughs in the future of health and health care. (www.healthgamesresearch.org)
Institute of Play	Working across a diverse community of players, the Institute of Play leverages games and play as critical contexts for learning, innovation, and change in the 21st century. It brings non-traditional audiences into innovative spaces of production and learning through partnerships with the game industry, academia, government, science, technology, and the arts. Through a variety of programs centered on game design, the institute engages audiences of all ages, exploring new ways to think, act, and speak through gaming in a social world. (www.instituteofplay.com)
K20 Center for Educational & Community Renewal	The K20 Center at Oklahoma University is an interdisciplinary research and development center focused on creating and sustaining interactive learning communities through action-oriented partnerships between schools, universities, industries, and community and governmental agencies. The K20 Center brings together interdisciplinary, cross-organizational teams to share ideas, observe best practices, identify and analyze problems, and develop strategies for improved teaching, learning, and community life. (k20network.ou.edu)

Center	Description
NYU Game Center	The NYU Game Center is a pioneering new university-wide academic initiative for the research, design, and development of digital games. The center will be a collaboration by faculty members in computer science, engineering, new-media theory, and the arts, and is the first step in establishing undergraduate and graduate programs in game design. The center is supported through a $1 million anonymous gift and a $200,000 grant from the Rockefeller Foundation. (gamecenter.nyu.edu)
PETLab	PETLab (Prototyping, Evaluation, Teaching and Learning), a joint project of Games for Change and Parsons The New School for Design in New York City, is a public-interest game-design and research lab for interactive media. PETLab is a place for testing prototyping methods and the process of collaborative design with organizations interested in using games as a form of public-interest engagement. PETLab works with scholars and designers in the field of digital media, practitioners working in the spheres of education and social issues, and people of all ages at play. Support for PETLab comes from the John D. Catherine T. MacArthur Foundation's Digital Media and Learning initiative. (petlab.parsons.edu)
The University of Texas Videogame Archive	The UT Videogame Archive of The Center for American History pre-serves and protects the records of video game developers, publishers, and artists for use by a wide array of researchers. The center not only collects and provides access to materials that facilitate research in video game history, but also provides materials of interest to those studying communications, computer science, economics, and other academic disciplines that are now, and will for the foreseeable future, be drawn to the processes driving the video game industry. The archive currently holds fourteen collections, including papers, games, and files of the archive's first three donors Richard Garriott, Warren Spector, and George "Fat Man" Sanger. (www.cah.utexas.edu/projects/videogamearchive/about.html)
USC—Electronic Arts Game Innovation Lab	The Game Innovation Lab in the USC School of Cinematic Arts is a research space and think tank where experimental concepts in game design, play, and interactive entertainment are developed, prototyped, and play-tested. The lab is the center of games research in the school's Interactive Media Division and the hub of a vibrant, investigative game community within the division. Founded in 2004 with a gift from Electronic Arts and directed by Tracy Fullerton, the lab promotes a culture of play-centric design and a strong focus on creating deeply emotional game play that has been instrumental in the development of several extremely influential independent and serious games, including *Cloud*, *flOw*, *Darfur is Dying*, *Hush* and *The Night Journey*. (interactive.usc.edu/research/games)

selected literature on children and digital media

Many researchers and government agencies remain understandably skeptical of the impact of games on children's early-learning habits and overall well-being. Some reports argue that popular digital media such as games are at least partially to blame for the literacy, obesity, and dropout crises in America, and point to evidence showing the negative impacts of sedentary television screen time.

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Koplan, J.P., Liverman, C.T., & Kraak, V.I. (2009). *Preventing Childhood Obesity: Health in the Balance*. Washington, D.C.: National Academies Press.

National Endowment for the Arts. (2007). *To Read or Not to Read: A Question of National Consequence*. Washington, D.C.: National Endowment of the Arts. Available at http://www.nea.gov/news/news07/TRNR.html. Accessed March 31, 2009.

Robinson, T.N. (1999). Reducing Children's Television Viewing to Prevent Obesity: a Randomized Control Trial. *Journal of the American Medical Association*, 282, 1561–1567.

Other reports find no relationship between media consumption and diminished engagement with traditional activities such as reading and active play. These also suggest that quality and balance are important considerations.

Greenfield, P. (2009). Technology and Informal Education: What is Taught, What is Learned. *Science*, 323, 69–71.

Vandewater, E.A., Bickham, D.S., & Lee, J.H. (2006). Time Well Spent? Relating Television Use to Children's Free-time Activities. *Pediatrics*, 117, 181–191.

Current games scholarship provides useful insights for how games are particularly suitable for learning. The key may be in striking the right balance of entertainment and teaching in order to capture the potential benefits of well-designed and successfully integrated digital games in various learning and health settings.

Gee, J.P. (2003). *What Video Games Have to Teach Us About Learning and Literacy*. New York: Palgrave/Macmillan.

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list of interviewees

For this report, we interviewed experts who are directly involved in the research, design, development, or implementation of games for learning, as well as experts on children's health. We thank the interviewees for taking the time to share their experiences in this area, as well as their hopes and concerns for its future.

· David Abrams, Ph.D., Executive Director, Schroeder Institute at the American Legacy Foundation and former Director Office of Behavioral and Social Sciences Research, National Institutes of Health

· Heather Chaplin, Author and Journalist; Member, National Public Lightpath

· Pat Christen, President and CEO, HopeLab

· Sara DeWitt, Senior Director, PBS KIDS Interactive

· Tracy Fullerton, Associate Professor and Director, Electronic Arts Game Innovation Lab, University of Southern California

· James Paul Gee, Ph.D., Mary Lou Fulton Presidential Professor of Literacy Studies, Arizona State University

· Alan Gershenfeld, Founder and President, E-Line Ventures

· Lawrence K. Grossman, Co-Chair, Digital Promise Project

· Craig Hagen, Corporate Director of Governmental Affairs, Electronic Arts, Inc.

· Henry Kelly, Ph.D., President, Federation of American Scientists

· Gary Knell, President and CEO, Sesame Workshop

· Debra Lieberman, Ph.D., Director, Health Games Research, UC Santa Barbara

· Rob Lippincott, Senior Vice President of Education, PBS

· Claudia McDonald, Ph.D., Associate Vice President for Academic Affairs & Special Projects, Texas A&M University-Corpus Christi

· Ernie Medina, Dr.P.H., ACSM-CHFS Co-Founder and CEO, XRtainment Zone

· Alex Quinn, Executive Director, Games for Change

· Diana Rhoten, Ph.D., Program Director, Knowledge Institutions; Research Director, Digital Media and Learning, Social Science Research Council; and former Program Director, Virtual Organizations and Learning and Workforce Development for the Office of Cyberinfrastructure, National Science Foundation

· Katie Salen, Associate Professor, Parsons The New School for Design; Executive Director, Institute of Play

· Ben Sawyer, Co-Founder, Serious Games Initiative; Co-Founder, Digitalmill, Inc., Games for Health

· Suzanne Seggerman, Co-Founder and President, Games for Change

· Benjamin Stokes, Co-Founder, Games for Change; Program Officer, Digital Media & Learning, MacArthur Foundation

· Craig Wacker, Program Officer, Digital Media & Learning, MacArthur Foundation

· Ellen Wartella, Ph.D., Distinguished Professor of Psychology, UC Riverside

· Connie Yowell, Ph.D., Director of Education, Program on Human and Community Development, MacArthur Foundation

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