Playpower:
Radically Affordable Computer-Aided Learning with $12 TV-Computers†

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ABSTRACT
The Playpower Foundation (Playpower.org) is using a US$12 computer as a platform for 8-bit learning games in order to improve educational access for millions of children around the world. Motivated by the availability of this radically affordable platform, our goal is to design and discover high-quality 8-bit learning games and make computer-aided learning affordable for people everywhere.

This paper outlines the general relevance of Computer-Aided Learning (CAL) to developing countries, sketches the historical background of our proposed platform, and proposes principles and methods to guide the future development of effective 8-bit content. We conclude by framing this project and its relevance in the context of a variety of contemporary cultural trends and research topics.

Keywords
Computers, Education, Computer-Aided Learning, 8-bit, Video Games, Design Revolution, Development

INTRODUCTION
Developing a skill as basic as touch-typing can be economically transformative. In the developing world it can make the difference between earning $1/day, as a rural farmer, and $1/hour, as a office worker. Similarly, children that learn computer programming skills have incredible opportunities to make economic and social transitions. As a platform to teach skills such as these, the Playpower Foundation (Playpower.org) is advocating the use of an 8-bit *TV-Computer* (TVC), which is commonly sold with a full keyboard and a mouse, as well as cartridges containing software for typing instruction and learning BASIC programming (figure 1). New TVCs are already being manufactured at a large scale and are sold at retail for as little as US$12. This low cost is due to the use of a pre-existing TV as an external display and the employment of a computer processor that is now in the public domain (the MOS 6502, used in the Apple II and the Nintendo Entertainment System®). Playpower's goal is to enhance the educational value of the TVC by introducing a core suite of high-quality 8-bit learning games. Furthermore, we are developing an open-source 8-bit game creation kit, to enable the design of region-specific content by individuals around the world.

Figure 1: Typical keyboard-style TV-computer with working mouse, game-pads, and game cartridges

A Global Problem
There are millions of children around the world who are unable access basic education. Government schools in developing countries are often ineffective and fail to teach their students even the most basic skills. For example, while more than 90% of rural Indian children attend primary school, nearly half of them cannot read simple sentences or perform simple math, according to the “Annual Status of Education Report 2005” (Pratham, 2006). Similarly, in Ghana, only 10% of 6th grade students passed the basic math exam in 2006—with nearly half of the students scoring close to chance, according to Ghana's 2006 National Educational Assessment (Adu, 2006). These students are attending school, but clearly are not learning much. This situation exists despite more than $12 billion in World Bank funding that has been spent on primary education in developing countries since 1990 (Economist,

† Lomas, D., Douglass, J., & Rehn, D. *Playpower: Radically Affordable Computer-Aided Learning with $12 TV-Computers.* Paper presented at the Meaningful Play 2008 conference, East Lansing, MI. Oct 9 2008.

2006). One common result of inadequate public education in developing countries is a thriving market for private educational services (Waldman, 2003), primarily in the form of private schools and tutors. However, these services are expensive, inconsistent (in terms of educational value) and largely unavailable in rural areas.

Computer-Aided Learning as a Solution

Computer-Aided Learning (CAL) is a solution that shows great promise as an effective mechanism for improving education in developing countries, particularly as an outside supplement to classroom learning (Linden, 2008). Once developed, CAL software can be scaled quickly and without great expense, while still providing a consistent instructional environment. Since there is a general skepticism about the role of CAL in developed countries, where it must compete with highly trained teachers and a wealth of traditional educational media, it should be noted that when CAL is implemented in developing countries, the educational benefits may be far more noticeable.

In a landmark study by MIT's Abdul Latif Jameel Poverty Action Lab (J-PAL), computer-aided learning was implemented in the Indian state of Gujarat (Banerjee, 2007) and evaluated using a rigorous methodology based upon randomized trials. In this study, 4th grade students played educational math games for 2 hours per week. In the first year, this program was found to have a wide and significant effect—with an average improvement of .37 standard deviations, and equal improvements by both boys and girls. While the program benefited under-performing students more than top performing students, researchers found significant improvements across the distribution. While this study found that CAL was slightly more effective at teaching math than the "Balsakhi" practice of hiring local women as assistant teachers, the authors concluded that the purchase of traditional PC computers was far less cost-effective.

Indeed, as of 2008, the most inexpensive computers still cost hundreds of dollars—a price that is unaffordable to the billions of people around the world who could most benefit from CAL. This is why we are promoting CAL software on 8-bit computers, which are effectively affordable to any family that already owns a television. This barrier, while not insignificant, includes millions more families than are currently able to afford home computers. In India, for instance, more than half of all households own a TV set (Bajaj, V. 2007).

THE PLAYPOWER PLATFORM, A $12 COMPUTER

"The $12 computer," as labeled by the press (Phillips, 2008), is a keyboard, mouse, and 1Mhz processor that connects to a TV screen. The keyboard, a self-enclosed unit that contains the processor and video card, has a "cartridge slot" that accepts plastic-encased chip cartridges. Cartridges use the 1980's era 8-bit Nintendo Famicom cartridge form factor, and a single cartridge can contain hundreds of software titles. This platform already serves as the basis for affordable computer-aided learning for millions of people around the world, and the Playpower Foundation intends to support this by ensuring that high-quality CAL software is made available for this machine.

The primary pragmatic reason for selecting the NES/Famicom architecture as a platform for affordable computer-aided learning is that the platform has been massively successful over the past 25 years, and as a result, it is still being broadly manufactured today. For years, dozens of manufacturers competed to produce illegal, pirate versions of the Famicom at low costs (manufacturers did not have a license to manufacture the device). As the original hardware patents have since expired, we can now leverage this mature and cost-efficient manufacturing ecosystem and distribution network for global education.

Brief History of the Famicom

The Famicom® (or "Nintendo Family Computer") is a Japanese 8-bit video game console which was produced for the United States as the NES® (or "Nintendo Entertainment System"). Originally released in 1983, it sold over 60 million units around the world, and remains one of the best selling video game consoles of all time. Over 1000 different games were released for the NES/Famicom.

Figure 2: Nintendo Famicom®

The core of the Famicom is a modified 6502 processor. Rather than using an operating system, Famicom software runs via the insertion of game cartridges that contain Read-Only Memory (ROM) on a chip. Alternately, the Famicom Disk System supported use of a writeable floppy diskette. This diskette drive and a number of other Japanese Famicom accessories will be unfamiliar to American users of the NES, who tend to think of the platform as only supporting game controllers. Over the lifetime of the platform, the Famicom also supported a cassette-based data recorder and a keyboard. Even a Famicom modem was released in 1987, when it was primarily marketed to older users as a way to trade stocks with their Family Computer.

For this project, a crucial event in the history of the Famicom was the 1984 Nintendo release of "FamilyBASIC," a Japanese product that included a full keyboard and a RAM expansion cartridge that enabled a form of BASIC programming. In addition to BASIC programming, the FamilyBASIC bundle included a word processor, a music editor, and a drawing program. An optional data recorder enabled users to save their creations using a cassette.

Figure 3: Family BASIC keyboard, cartridge, and cassette data recorder connect to the Famicom System

Famicom Clones

Dozens of manufacturers have cloned this FamilyBASIC Famicom and embedded all of the processors inside the keyboard, which connects directly to game controllers and a TV. These keyboard clones generally come packaged along with traditional game controllers, a lightgun, and a working mouse. There is also occasionally custom software, including a lightweight desktop-metaphor Graphical User Interface (GUI). This GUI is either embedded into system ROM or contained within the included cartridge.

In addition to the keyboard-style clones that have entered mass-production in the past few years, over 350 different types of "Famiclones" have been manufactured over the past 20 years. Many recent Famiclones use NES-on-a-chip (NOAC) architecture. NOAC use miniaturizes and further reduces cost, but cause compatibility issues with some original software that used advanced memory mapping (e.g. Castlevania III). Earlier Famiclones were typically packaged with two game controllers and a light gun but without a keyboard or mouse. For many years Nintendo initiated legal action against companies making or distributing clones, but since the expiration of patent protections, no such lawsuits have been initiated since 2005.

History of the 6502 and the Home Computer Revolution

It is worth noting that the 8-bit 6502[2] chip technology (along with the Zilog z80) was the basis for most of the computers that catalyzed the post-1977 "home computer revolution" period in both America and Europe. These early 6502 home computers include the Apple II, the BBC Micro, TRS-80, Sinclair Spectrum, Commodore PET and the VIC-20. These were the first computers to achieve widespread use by consumers due to their low price. Like keyboard-based Famiclones today, these early home computers were also commonly connected to a TV display to reduce cost. Most were marketed for education, gaming, and personal productivity (such as word processing), and nearly all featured the BASIC programming language. In U.S. culture, the Apple II is especially notable for its longevity: this model was very common in American schools for over a decade, engaging an entire generation with its 8-bit learning games. Some famous examples include Oregon Trail, Number Munchers, and Lemonade Stand, all of which were produced by the Minnesota Educational Computer Consortium (MECC).

CREATING REAL IMPACT WITH AN 8-BIT COMPUTER

As slow as 1Mhz 8-bit computers appear in comparison to contemporary machines, 8-bit programs are certainly powerful enough to be engaging. A recent trend in console gaming is the launch of dedicated online stores that sell early 8-bit and 16-bit game catalogs to owners of cutting edge video game systems, such as the Nintendo Wii Virtual Console. These 8-bit software marketplaces appear to have been both popular and lucrative.

8-bit computers also have a successful track record in teaching basic skills for reading, writing, mathematics, science and other subjects such as computer programming, as demonstrated by various software titles developed for computers like the Apple II or Commodore 64. Even complex abilities like creative problem solving, critical thinking, logic, and entrepreneurship can be fostered through exploration of well-designed 8-bit game environments. However, there is very little existing instructional software available for the NES/Famicom, and it is not an easy task to port software from the Apple II and other 8-bit systems. This poses a serious problem for adoption of the keyboard-style Famiclone TVC as a major platform for computer-aided learning.

In its current state, there are significant challenges to the provision of educational experiences via the TVC. There is little software for teaching math or other curricula, and even the available typing games seem insufficient to teach proper touch-typing. Similarly, with only a BASIC prompt

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[2] The 6502 lives on: it is still common for computer science departments to use the chip as the basis for teaching assembly programming

(and no supplementary media), it is unlikely that many children will learn programming skills from the TVC. One mitigating factor is that the TVC does introduce elements of fundamental computer literacy, such as typing and mouse use. Such exposure to simple computing may serve to support a child's confidence and interest in engaging with more advanced computers. Nevertheless, in order to maximize the educational potential of the TVC, it will be necessary to produce new, high-quality 8-bit content.

Creating an Open-Source 8-bit Development Kit

The issue with developing new content for the NES/Famicom TVC is that it requires *assembly coding*, which is a difficult and specialized skill. This makes it impractical to follow a traditional model of paying hired developers to produce new content, especially as this would limit developer participation and the variety of the resulting products. Therefore, our goal is to develop an open-source development kit that will make it far easier to program learning games. To accomplish this we plan to build on nBASIC, a high-level framework for building assembly code that uses BASIC programming conventions (Rost, 2004). Combining nBASIC with the complete documentation of the NES (Diskin, 2004) forms the core of our open-source programming kit. This simplified programming environment will aid developers from around the world in building or modifying their own 8-bit games, creating an ecosystem of 8-bit content to support regional languages, local educational needs, and diverse cultural expression.

Design Constraints of 8-bit Computing

Programming aside, there are numerous constraints on the design of 8-bit content. For instance, 8-bit computing allows for some basic voice synthesis, but it lacks rich multimedia and realistic 3-D graphical environments. Nevertheless, we hope that these design constraints can be productive (Collins, 2007). 8-bit visual design requires highly simplified graphical representations and animations—leaning heavily on the imagination of users to 'fill in the blanks.' Good 8-bit interaction design will require increased emphasis on text, timing, educational content, and explicit support for the extrinsic motivations that surround specific learning tasks. (For an example of this extrinsic motivational design, consider in-game text that explains how a learning game skill is used within a particular profession, while also stating the average salary.)

While 8-bit software is commonly associated with a bygone stage of computer history, we do not view 8-bit as obsolete. 8-bit is, rather, a wholly different medium for expression. Why is the classic 8-bit game Super Mario Bros. still incredibly fun and popular, even in an age of 128-bit graphics? Why do 8-bit games remain popular on websites, mobile devices, and even next-generation consoles? One answer, suggested by N. Katherine Hayles "Media Specific Analysis" approach to new media and literary criticism (Hayles, 2004) is that the material constraints of a form are inseparable from it's unique expressive capacity. Like black-and-white versus color photography, cartooning versus photorealism, or super-8 versus Technicolor, 8-bit graphics and audio offer constitutive aesthetic constraints that help them to communicate, and these are valuable in their own right.

Social Design and Participatory Learning Games

8-bit games have substantial limits on their expressive qualities and interaction affordances. However, by designing learning games that induce social interactions, the power of the game can extend outside the screen. Playpower.org is specifically interested in designing games that yield *participatory learning environments* to support cooperation, competition, and conversation among both game players and observer-participants. We hope to design learning games that generate social learning experiences by engaging groups of friends and family—groups that already typically congregate around household televisions. This will extend the educational reach of the platform beyond individual users and into wider networks such as neighborhood peers. It will also use the social context to support the individual's learning process. These types of social learning experiences may be easier to generate around TVs than around PCs or Laptops, which is an additional benefit of the form factor of our platform.

Social factors have long been used to motivate advanced game play (i.e. "High Score" leader boards) and we wish to evaluate the impact of these factors on motivations to excel at Computer-Aided Learning games. Games can provide incentives for skill development by producing valuable social capital at high-levels of performance, such as through unexpected and exciting game changes at advanced levels, secret content, or even by providing elements of Alternative Reality Games (ARGs). One hallmark of ARG design is the loose incorporation of mixed media such as websites, software, telephone networks, mail systems, and geographic exploration. While many 8-bit TVC users may have, at best, periodic internet access via internet cafés, educational engagement with real-world systems such as local transportation and communication systems might still be motivated by embedding ARG-like game elements into 8-bit ROMs. Experimental social learning games need to be evaluated for efficacy, but they may hold great impact, especially for target populations with unevenly distributed or sporadic access to a variety of services.

The Other 90%: CAL Games for Direct Economic Impact

"The majority of the world's designers focus all their efforts on developing products and services exclusively for the richest 10% of the world's customers. Nothing less than a revolution in design is needed to reach the other 90%" claims Paul Polak, founder of International Development Enterprises (Polak, 2008). What is the nature of this other 90%? Research by the World Bank (Chen, 2008) shows that over 5.1 billion people live on less than $10 per day (Ravillion, 2008), which includes 95% of the population of developing countries. Beyond this, 3.14 billion people live on less than $2.50 (Chen, 2008) and another 1.4 billion living on less than $1.25 (the global poverty line). (In fact, actual income is substantially less than this, but it is adjusted higher in a process known as Purchasing Power Parity) Polak reminds us that, for people to rise out of poverty, "it all starts with making more money." He advocates the design of products that can pay for themselves in their first year, like his $3 drip irrigation kit (Polak, 2008).

Education can rarely pay for itself within a year, but nevertheless, Paul Polak's advocacy suggests that the most important computer-aided learning games are those that can provide direct economic impact for their users. For example, developing typing skills can substantially increase a person's economic opportunities: Worth (2002) and Thomas (2003) report that typists in Ghana make between three to ten times the minimum wage. Entrepreneurial or small business skills can also generate economic benefit—leading us to consider deploying a version of one of the numerous, existing 8-bit games that base success upon mastering simulated market forces (e.g. Lemonade Stand or M.U.L.E.). Math skills can yield direct benefits, especially for jobs that involve monetary transactions. In fact, any skill learning games that increase a child's chance of passing their exams or continuing their education will yield significant economic benefits, though this may take place over many years. Other types of skills that should be considered include health education, life planning, and even agricultural techniques.

Rev. George Fuachie is a resident and community leader in the Kintampo North District of Ghana who worked with the team at Amy Smith's International Development and Design Summit (IDDS) at MIT to establish the feasibility of the TV-Computer. Fuachie identified several areas as useful focal points for the development of computer-aided learning games or software on the TVC (McIver, 2008):

- Math, literacy, and critical thinking skills for basic primary education;
- Preparation for entrance exams into junior high level;
- Preparation for secondary and tertiary level exams;
- Adult literacy and numeracy; and
- Basic job skills, such as typing and accounting.

Addressing Skill Shortages in Developing Countries

There is an unexpected skills shortage in developing countries, especially in Asia. As the Economist (August 16, 2007) commented: "It seems odd. In the world's most populous region the biggest problem facing employers is a shortage of people." Indeed, it is surprising for many people to discover that India, in particular, is facing a massive skills shortage. The outside perception of India is a country filled with young, highly trained English-speaking engineers just waiting to snap up available technology jobs. This perception is "bogus" according to Mohandas Pai, Director of Human Resources at Infosys (India's second-largest software services company). Recently interviewed in the Deccan Herald, he said, "the single biggest factor that is going to hurt India…is not the lack of power, nor lack of roads, but it is lack of qualified people." (Singh, 2008) The New York Times has also reported on this issue (Sengupta, 2006; Rai, 2006). Computer-aided learning and computer literacy may help mend this gap in the workforce.

Contextual Design Method for Learning Games

Within a given cultural ecology, many skills are associated with success and economic opportunity. Ethnographic methods can both identify these skills and aid the design of learning games that support targeted skill development. Matthew Kam and John Canny of Berkeley have pioneered various techniques for the contextual design of learning games in developing regions (Kam, 2006; Kam, 2008). Their iterative participatory design process (Kam, 2007) has generated great insight into the development of English Language learning games, and may serve as a model for the subsequent contextual design of learning games for the $12 TV Computer. We hope that the affordability and availability of this platform, combined with an easy-to-use development kit, will create a rich development ecosystem that can stimulate the localized design of learning games based upon regional needs and interests.

Educational Value of Existing NES Games

Many non-educational video games have been described as rich learning environments that support intellectual growth, just as puzzles and riddles have traditionally been seen as both diversions and intellectual exercises. Seymour Papert (Papert, 1998) and James Paul Gee (Gee, 2003) describe the game industry as a Darwinist ecology that has evolved a veritable treasure trove of interaction designs that support learning processes—because the nature of a game is to demand a user to develop specific skills and competencies in order to achieve success. In fact, the experience of "fun" in gameplay has been described as cognitive feedback rewarding the experience of learning itself (Koster, 2005). Games may require learning in order to play, but Ian Bogost has also shown that games can teach concepts and principles, through what he describes as "procedural rhetoric" (Bogost, 2007). In their "Values at Play" game curriculum initiative, Flanagan, Howe, and Nissenbaum take a related approach to analyzing how ethical and social values are both encoded in game designs and expressed through various modes of gameplay (Flanagan et al, 2005). Using the historical archive of NES games at the UC San Diego Game Libratory, Playpower hopes to identify a set of existing games that would best support a cognitively enriching learning environment. Thousands of games were developed for the NES/Famicom, and although all of these games remain protected by copyright (and would therefore require licensing for redistribution), some are certain to be of great value to a child's development simply through the power of play.

8-bit Culture and Community Formation

There is a general contemporary cultural movement exploring 8-bit audio and image aesthetics that tends to embrace both "retro" and "R&D," trading in nostalgia but also researching the limits of simple computational systems and developing new uses for them. What is notable about this 8-bit movement is that it generally assumes that the aesthetic constraints of 8-bit computation are part of a valid medium suitable for serious expression. Examples of serious 8-bit perhaps reach their culmination in 8-bit art movements such as "8bitpeoples" (Loftus, 2003). Other notable references to the historical and contemporary 8-bit art genre include the global DemoScene (Scheib, 2002), ANSI art groups like "Acid Productions," and pixel art groups like the community "Pixel Joint." Other current examples of mainstream cultural production include the 2008 television show "Codemonkeys" animated primarily in 8-bit graphics and the forthcoming video game "Mega Man 9. "

One of the benefits to the adoption of a vintage hardware standard as a low-cost platform is that established developer communities have shown interest in partnering with Playpower for CAL game production. Further connections can be made to the numerous communities that continue to be enthusiastic about 8-bit cultural production, including the aforementioned art groups as well as emulator, hardware hacker, and homebrew gaming communities. These communities have already produced a multitude of valuable open-source resources for NES development, such as the complete NES Documentation (Diskin, 2004), which emerged out of the nesdev.parodius.com community. We hope that these groups will continue to build tools, as well as contribute assets such as sound, graphics, or code that can be integrated into the open-source 8-bit game creation kit. Through this ongoing activity, Playpower seeks to establish valuable social bridges between the 8-bit enthusiast sub-cultures (whether they be 8-bit artists, hackers, geeks, or otaku) and the communities in developing countries that we wish to serve.

CONCLUSION

The Playpower Foundation is using an old game platform technology as the basis for a radically affordable approach to computer-aided learning. In adopting 8-bit hardware, we are also promoting the validity and value of early games and computing approaches in our age. As we reconsider the valuable design constraints of that era, we wish to experiment with the creation of new participatory learning environments by designing 8-bit games that engage the social context surrounding the household TV. Our primary pedagogical approach, however, is focused on the expansion of economic opportunity for the children of developing countries through classic computer-aided learning routines based primarily upon extrinsic motivations. Part of the power of our platform is the context of play within which computer-aided learning will occur. If we are successful at establishing the 8-bit TVC as an effective and affordable platform for the improvement of education in developing countries through computer-aided learning, we hope for the emergence of a profitable ecosystem for local game development that triggers new 8-bit cultural traditions and the production of regional video games as valuable cultural artifacts.

ACKNOWLEDGEMENTS

Many thanks to Amy Smith and all the participants and mentors of the International Development Design Summit (IDDS), especially Jesse Austin-Breneman, Miguel Chavez., Rev. George Fuachie, William McIver, and Anuj Nanavati. Much appreciation also goes out to the California Institute of Telecommunications and Information Technology (Calit2) especially Srinivas Sukumar. We also wish to acknowledge CRCA director Sheldon Brown, Software Studies director Lev Manovich, the Game Library at UC San Diego, all past contributors to the Social Movement Laboratory, and the Srishti Center for Experimental Media Arts (CEMA) in Bangalore.

REFERENCES

1. Adu, J. K. (2006). Report on 2005 Administration of National Education Assessment Primary 3 and Primary 6. *Basic Education Comprehensive Assessment System*.
2. Bajaj, V. (2007, Feb 11). In India, the Golden Age of Television Is Now. *New York Times*.
3. Banerjee, A. V., Cole, S., Duflo, E., & Linden, L. (2007). Remedying Education: Evidence from Two Randomized Experiments in India. *The Quarterly Journal of Economics*, *122*(3), 1235-1264.
4. Bogost, I. (2007). *Persuasive Games: the expressive power of videogames.* Cambridge, MA: MIT Press.
5. Bogost, I. (2008). *Platform Studies*. Paper presented at the SoftWhere 2008, San Diego, CA.
6. Brewer, E., Demmer, M., Du, B., Ho, M., Kam, M., Nedevschi, S., et al. (2005). The Case for Technology in Developing Regions. *Computer*, *38*(6), 25-38.
7. Chen, S. & Ravalliono, M. (2008). *The Developing World Is Poorer Than We Thought, But No Less Successful in the Fight against Poverty* (Policy Research Working Paper WPS4703 ed.). Washington, DC: The World Bank.
8. Collins, K. (2007). In the Loop: Creativity and Constraint in 8-bit Video Game Audio. *Twentieth-Century Music*, *4*, 209-227.
9. Collins, S. (1998). Game graphics during the 8-bit computer era. *SIGGRAPH*, *32*(2), 47-51.
10. Diskin, Patrick. (2004) Nintendo Entertainment System Documentation. http://nesdev.parodius.com/NESDoc.pdf
11. Economist (2006, Jul 13). Are Our Children Learning?

The Economist.

12. Economist (2007, Aug 16). Asia's skills shortage. *The Economist*.
13. Flanagan, M., Howe, D., Nissenbaum, H. (2005) *Values at Play: Design Tradeoffs in Socially-Oriented Game Design.* Proceedings of the SIGCHI conference on human factors in computing systems 2005, Portland, Oregon, USA
14. Frasca, G. (2004). Videogames of the oppressed : critical thinking, education, tolerance, and other trivial issues. In N. Wardrip-Fruin & P. Harrigan (Eds.), *First Person : new media as story, performance, and game*. (pp. 85-94). Cambridge, MA: MIT Press.
15. Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment (CIE)*, *1*(1), 20-20.
16. Gibson, J. M. (2006). *I Am 8-bit: Art Inspired by Classic Videogames of the'80s.* Chronicle Books.
17. Grant, R. M. (2004). Case eleven: Rivalry in Video Games*. Contemporary Strategy Analysis*.
18. Hayles, N. K. (2004). Print is Flat, Code is Deep: The Importance of Media-Specific Analysis*. Poetics Today*, *25*(1), 67-90.
19. Juul, J. (2005). *Half-real : video games between real rules and fictional worlds.* Cambridge, MA: MIT Press.
20. Kam, M., Agarwal, A., Kumar, A., Lal, S., Mathur, A., Tewari, A., et al. (2008). *Designing e-learning games for rural children in India: a format for balancing learning with fun*. Paper presented at the Designing Interactive Systems (DIS) 2008, Cape Town, South Africa.
21. Kam, M., Ramachandran, D., An, Raghavan, Chiu, J., Sahni, U., et al. (2006). *Practical considerations for participatory design with rural school children in underdeveloped regions: early reflections from the field*. Paper presented at the IDC 2006, Tampere, Finland.
22. Kam, M., Ramachandran, D., Devanathan, V., Tewari, A., & Canny, J. (2007). *Localized iterative design for language learning in underdeveloped regions: the PACE framework*. Paper presented at the CHI 2007, San Jose, CA.
23. Koster, R. (2005). *A Theory of Fun for Game Design.* Scottsdale, Arizona: Paraglyph Press.
24. Linden, L. L. (2008). Complement or Substitute? The Effect of Technology on Student Achievement in India*. InfoDev Working Paper 17.*
25. Loftus, T. (2003, Oct 1). Play that funky music, Game Boy: Artists embrace the bleeps and bloops of vintage video gaming. *MSNBC*.
26. McIver, W., Austin-Breneman, J., Santos, M. C. d., Fuachie, R. G., Lomas, D., Nanavati, A., et al. (2008). *The $10 TV Computer Project: Current Results*. Paper presented at the International Development Design Summit.
27. Montfort, N. & Bogost, I. (Eds.). (2008). *Video Computer System: The Atari 2600 Platform*. (Forthcoming ed.). Cambridge, MA: MIT Press.
28. Papert, S. (1998, Jun). Does Easy Do It? Children, Games, and Learning. *Game Developer*, p. 88.
29. Phillips, A. (2008, Aug 7). Researchers Propose $12 Computer for Developing Countries. *ABC News*.
30. PMEI. (2007). *Pratham Annual Report 2006-2007.* Mumbai: Pratham Mumbai Education Initiative.
31. Polak, P. (2008). *Out of Poverty.* San Francisco, CA: Berret-Koehler.
32. Polgár, T. (2005). *Freax: The Brief History of the Computer Demo Scene Volume I.* CSW-Verlag.
33. Rai, S. (2006, Feb 16). India's Outsourcing Industry Is Facing a Labor Shortage. *New York Times*.
34. Ravallion, M., Chen, S., & Sangraula, P. (2008). *Dollar a Day Revisited* (Policy Research WPS4620 ed.). Washington, DC: The World Bank.
35. Rost, B. (2004). nbasic Language Reference Manual. Updated March 15, 2004. http://bobrost.com/nes/files/nbasic_manual.html
36. Scheib, V., Engell-Nielsen, T., Lehtinen, S., Haines, E., & Taylor, P. (2002). *The demo scene*. Presented at the ACM SIGGRAPH 2002, San Antonio, Texas.
37. Sengupta, S. (2006, Oct 17). Skills Gap Hurts Technology Boom in India. *New York Times*.
38. Silvast, A. & Reunanen, M. Demoscene bibliography. Retrieved 2008-09-15, http://www.kameli.net/demoresearch/bibliography.php
39. Singh, A. & Sharma, S. (2008, Aug 20). Skilled labour shortage threatens expansion in India. *Deccan Herald*.
40. Strover, S. & Pelletier, E. (2003). Digital Games in Education and Training: a bibliography. Retrieved 2008-09-15, http://www.utexas.edu/research/tipi/reports2/Video%2520Game%2520Bibliograpy%2520August%25202003.pdf
41. Waldman, A. (2003, Nov 15). India's Poor Bet Precious Sums on Private Schools. *New York Times*