DESIGN THESIS

MiD @UArts

12.15 2010

Matt Miller
Jake Wells

Build Play Learn

An analysis of hands-on learning and virtual learning for their effectiveness in creating rich learning experiences which translate to the physical world.

Matt Miller & Jake Wells

GRID 711: Thesis Proposal, December 15, 2010

An analysis of hands-on learning and virtual learning for their effectiveness in creating rich learning experiences which translate to the physical world.

Abstract

Children define their world through their experiences. Historically, children have played with toys based in physical reality. They played with blocks and bricks and built model rockets and box-cars. These experiences translated real-world understanding since this is where the experiences were based. Now, children play with digital toys and video games where play is based in virtual simulations. The question remains, however, as to how concepts learned in a virtual world translate to the real-world.

Our project will put this question to the test: we will design a series of exercises that test the effectiveness of hands-on learning, virtual learning, and a combination of both. We will measure each learning method for the translation of learned concepts to real-world applications. Based on our findings, we will design a toy that combines the best of both worlds.

Problem

According to Piaget's model of cognitive development, between the ages of 7–11 a child's development is characterized by inductive reasoning—children learn generalized laws from particular instances and experiences **(Kolb, 1984)**. In other words, what children experience during this time of their life shapes their understanding of the laws of reality. Historically, children at this age spent time working and building. They played with bricks and blocks and built model cars and rockets. Nowadays, children spend their time on the computer and playing video games—their understanding of the world is now rooted in this virtual simulation. Consider that 69% of children ages 11–14 have handheld video game players. Children ages 8–18 spend on average 1.13 hours per day playing video games and over 10 hours total per day consuming all types of media **(Kaiser Family Foundation, 2010).** Furthermore, consider recent Nielsen reports that 31% of children ages 6–12 want an iPod touch or computer **(NielsonWire, 2010).**

Studies show that certain concepts are be best understood with hands-on interaction with real-world, physical parts **(Perdue, 2009).** Yet video games that children play on the iPad, Gameboy, etc don't provide this type of hands-on interaction. This situation is also seen in schools where, in an attempt to engage students, are creating digital classrooms. For example, the NY Public School's program Quest to Learn incorporates video games as way to engage and teach **(Corbett, 2010)**. While their ability to engage is clear, there is still concern over the effectiveness of traditional video games as learning tools. Furthering the digital trend, the introduction of the iPad is creating an increase in digital textbooks. These textbooks, while they do feature engaging interactivity within virtual environments they still do not incorporate hands-on learning.

Some argue the influx in digital toys and games has created a generation of children that consume technology rather then create with it. As **Mitchel Resnick (2006) explains**, "Children have many opportunities to interact with new technologies—in the form of video games, electronic storybooks, and 'intelligent' stuffed animals. But rarely do children have the opportunity to create with new technologies..." Of course, there are good examples of toys that allow children to create with technology. For example, LEGO mindstorms and the Arduino microprocessor allow children to build working robots and electronic circuits—whatever they can imagine! However, access to these toys is often limited by price. Furthermore, these traditional toys are less likely to appeal to iPod yielding children.

Still, such digital toys have their downside. In a critical response to the much acclaimed MIT Siftable blocks (smart blocks that recognize and interact with each other) father and writer **Peter Nelson (2009)** argues these blocks limit a child's creativity and imagination. "...everything a Siftable does is one more thing the child playing with it can't invent, one more creative opportunity he no longer has, one more thing he can't do himself, because it's being done for him, by a block with a brain in it, and in the end, one more reason not to use his imagination, and one more reason to disengage." Nelson makes a strong case for the simple wooden blocks we grew up with as kids. By building a tower from blocks, you own the tower. You didn't just observe the tower, you built it from the ground up. You realized the large square block was better suited for the base after feeling the tower lean under it's weight. You rebuilt the tower after it fell. This is exactly the interaction, as we move into the digital environment, that gets lost in translation.

However, there is hope. IDEO founder David Kelley, in the award-winning series *The Promise of Play,* explains that when it comes to hands-on and digital “What we can hope for the most is that kids don’t do one or the other, that they do both. And those are the kids who I think will grow up with a self-image and a balance that will make them innovative people.”

Hypothesis

By combining hands-on and virtual learning in a way that best utilizes the affordances of each, we can create a richer learning experience (measured by attention, concept development, and problem solving) than would be the case if only hands-on learning or virtual learning were used.

Thesis

Learning (defined as the ability to acquire new skills and/or concepts and apply them to new contexts) is most effective when hands-on and virtual learning methods are combined. Each method has unique affordances: virtual simulations are more efficient for exploring (**since the learner is** not limited by space, cost, etc.) while hands-on skills **are more effective to show how a** learned concept **works in** the physical world **(since the learner is able to work with three-dimensional forms defined by space and gravity)**.

The Project

Our goal is to design a toy that combines hands-on and virtual learning in a way that best utilizes the affordances of each to create a richer learning experience. To determine which affordances these are, we will design a series of experiments that use simple exercises and challenges to test the effectiveness of solely hands-on learning, solely virtual learning, and a combination of both.

We will measure our effectiveness at creating a richer learning experience using the following criteria:

1. How long does it hold the child’s attention?
2. How quickly does the child learn the concept?
3. How well do learned concepts translate to physical reality?
4. How well do learned concepts translate to new problems in a different context?

If our hypothesis is correct, the richest learning experience will be a combination of both hands-on and virtual learning which leverages specific affordances of each.

This project will take place in 3 main phases:

1. Design exercises (hands-on, virtual, and combination) and method for testing the effectiveness of these exercises
2. Test with children, using small group sizes, between ages 8–14, one exercise per group.
3. Synthesize the results and design a toy based on findings.

Phase 1: Design exercises and challenges

To test our hypothesis we will design three simple exercises for children ages 8–14. Each exercise will provide a collection of parts, an environment (hands-on or virtual) to explore these parts, and reference material that explains basic concepts related to the parts. To test the effectiveness of these exercises we will design a hands-on challenge to be completed after the learning exercise. The following are examples of the these exercises and challenges:

Exercise 1: Hands-on learning exercise

Physical parts will be provided in the form of gears of various diameters. A board with holes will allow children to place the gears in different locations. An instructional paper will explain basic concepts of gears, for example how motion transfers from one gear to the next and how diameter effects gear speed. Children will have time to interact with these parts and reference the instructional paper. They will need to learn the basic concepts of gears in order to solve the provided challenge.

Exercise 2: Virtual learning exercise

The platform for this will be the Apple iPad and a simple application will be designed. The application will provide a collection of digital gears. Taking advantage of the digital medium, children will be able to change the diameter of each gear. These gears can be placed onto a digital board. They will behave the same as gears do in the real-world meaning they will behave according to laws of physics, motion, etc. Similar to the first exercise, basic reference materials will be provided. However, this application will leverage the affordances of the digital medium to provide additional layers of reference.

For example, gear ratios will be calculated and displayed in real time as children place gears together and change their diameters. No physical gears will be provided. Children will complete this exercise by solving a challenge.

Exercise 3: Test a combination of hands-on and digital learning.
We will provide both the physical parts and the digital application previously explained. If our hypothesis is true, learning will be richer in this third exercise.

Challenge 1: Directly applying learned concept
This hands-on challenge will be setup as follows: the board will have a two fixed gears, each in opposite corners. The first gear will have a handle so the child can rotate it. The second gear will activate a small LED when it rotates clockwise. The goal will be to use the provided gears to connect the first and second gears and activate the LED.

Phase 2: Test with children
We will test the effectiveness of the exercises we have designed with children between the ages of 8–14. Each exercise will be given to a different group. They will participate in the exercise and will be tested during and after using the evaluation method below. After the exercise is complete they will be given a challenge designed to test the richness of their experience and their ability to apply the newly learned concepts to a real-world, physical challenge.

Method for evaluation
We will design a method for testing their effectiveness of these exercises based on the following criteria:

1. **How long does the exercise hold the child's attention?**
   This will be measured by time spent engaged with the exercise and tendency to return to exercise, even after completing the challenge.
2. **How quickly does the child learn the concept?**
   This will be measured by the length of time spent with the exercise before the child solves the challenge.
3. **How well does the learned concept translate to new problems in a different context (problem solving)?**
   This will be measured by offering the child to a new challenge after they

complete the test exercise. This new challenge will apply the concepts learned from the test exercise in a new context that is not obviously similar to the test exercise.

Currently we are working to secure locations for testing our exercises. The coordinators of the *AIA: Constructing Toys* exhibit have expressed interest—they will be hosting a number of school trips to the exhibit during the month of January. We have started a dialogue with Brad Bartley, a UArts alumni and Senior Exhibit Designer at the Franklin Museum. We will be meeting with David Cooper Moore, Program Director and Curriculum Developer at Powerful Voices for Kids, a partnership between Temple University's Media Education Lab and the RussellByers Charter School in Center City Philadelphia.

Phase 3: Synthesize the results and design a toy based on findings

Our research will be realized in toy that combines the affordances from hands-on learning and virtual learning that best translate to real-world physical applications. We have already played and analyzed a small sampling of toys. These toys range from high-tech (all virtual) to no-tech. LEGO Mindstroms, we believe, is a good example of a toy that combines both virtual (through programming software) and hands-on (through building blocks). An example of a video game that affords children the ability to invent is Crazy Machines. The game challenges you to create Rube Goldberg style machines in order to advance through a series of levels. You have at your disposal a collection of cartoon style parts, for example swinging boots, floating balloons, steam generators, light switches, pulleys, ropes and more. Many similar games exist in the market. While these games are engaging we believe there is room for improvement. Since the parts in the games are unrealistic and interaction with these parts is limited to within a virtual environment, we believe that concepts learned in this game do not translate to the physical world.

Another example of a virtual application is the LEGO DeisgnByMe application. For years LEGO struggled to market a computer based building application. The problem is that the appeal of LEGOs doesn’t translate into the digital realm—the appeal is in the hands-on manipulation of the bricks. You can feel bricks click together. You can easily view what you are building from any angle. You can spread LEGO bricks out across the floor and see what you are working with. This is all lost in a virtual simulation where interaction is reduced to clicking a mouse and keyboard.

We believe our toy will have the following affordances which have been defined through our research thus far as criteria for effective play:

1. A flexible and set of tools*
2. modifiable set of rules that are based on real-world constraints*
3. environment affording both open-ended and challenge based learning (empower child to create their learning environment)*
4. role-playing*
5. guidance available when needed**
6. relates experience to real world, practical examples**

*defined by Frog Design (Richardson, Laura Seargeant, 2010) in the FastCompany article: Frog Design: The Four Secrets of Playtime That Foster Creative Kids.
***defined by the Tinkering School, Gever Tulley*

Benefit/Value/Impact of the Idea
If we consider Piegat's developmental theory that children between the ages of 7–11 reason laws that shape their world based on their experiences, then it's critical that these experiences can be related to the real-world. If children play in virtual simulations during this time, it may be the case that they miss an important area of understanding. Let's imagine that a child who only plays video games and grows up to become an engineer. He receives all the theoretical training necessary for this and spends his time optimizing data and running simulations. When he enters into the field, he finds himself not able to envision things beyond the simulations. When something breaks, it's the older engineer, the one who grew up building and working hands-on, that is able to take things apart, envision a new solution, and fix the problem.

In his Book titled *Play*, author Stuart Brown explains such a scenario: the newly minted engineers, who were trained in theoretical concepts but lacked skills gained through working with their hands, lacked the ability to envision new solutions in the way their fathers and grandfathers were able to.

Research & Literature

Hand-on learning

These schools are teaching children hot to build and create with real-world tools and objects. Children as young as second grade are empowered to build and create. Bringing back the shop class is an important concept. The Perdue study discovered that teaching by having children make something, rather than just reading theory, was most effective.

- Tinkering School, TED: Gever Tulley teaches life lessons through tinkering. *2009,* *http://www.ted.com/talks/gever_tulley_s_tinkering_school_in_action.html*
- Studio-H, Emily Pulliton
- Exploring the Effectiveness of an Interdisciplinary Water Resources Engineering Module in an Eighth Grade Science Class. *Perdue, 2009, http://news.uns.purdue.edu/x/2009a/090128DarkStudy.html Jody L. Riskowski, Carrie Davis Todd, Bryan Wee, Melissa Dark, Jon Harbor*

Educational Theory

This paper discusses learning theory, including that of Piaget. We are focusing on the third phase, from ages 7–11. Piaget's model of learning and cognitive development is explained.

- Kolb, D.A. Experiential learning: experience as the source of learning and development. Englewood Cliffs, NJ: Prentice Hall. 1984.

Virtual learning in education

Some schools are implementing video-game based curriculum to mixed reviews. It remains to be seen if this is an effective learning tool.

- Learning by Playing: Video Games in the Classroom. *Sara Corbett, September 15, 2010 http://www.nytimes.com/2010/09/19/magazine/19video-t.html?_r=3&pagewanted=1*

Critics of virtual learning

Children are more likely to be consumers of technology rather than empowered to create with it. When it comes to digital toys, the more the the toy does the less the child can imagine it to do, the less the can invent with it, and the less creative they become.

- Why “Siftables” (They’re New Digital Blocks from MIT) Are Not, Not, Not Better Than Regular Blocks. *Peter N. Nelson, September 17, 2009 http://thefastertimes.com/stayathomedads/2009/09/17/froebels-theory/*
- Computer as Paintbrush: Technology, Play, and the Creative Society. *Mitchel Resnick MIT Media Laboratory, Published in: Singer, D., Golikoff, R., and Hirsh-Pasek, K. (eds.), Play = Learning: How play motivates and enhances children's cognitive and social-emotional growth. Oxford University Press. 2006.*

On the topic of play

Play is important for the development of children, especially during the ages of 6-12. Ideal play, according to Frog Design, includes the following: (1) **Open environments** where child gets to be the author (2) **flexible tools** that allow children explore new uses of existing objects (3) **modifiable rules** that are open and flexible within parameters and (4) t**he analogy of superpowers** where children can picture themselves in the environments they create, rather then picture themselves through a character.

- Book: Play: How It Shapes the Brain, Opens the Imagination, and Invigorates the Soul, by: Stuart Brown and Christopher Vaughan
- Howard Chudacoff, 2009, lecture. Author of: Children at Play: An American History. http://www.youtube.com/watch?v=201hGBiFdjY
- Book: Play Reconsidered, by: Thomas S. Henricks
- Richardson, Laura Seargeant. Frog Design: The Four Secrets of Playtime That Foster Creative Kids. Published in FastCompany. 2010. http://www.fastcodesign.com/1662826/frog-design-the-four-secrets-of-playtime-that-foster-creative-kids

Hands-on project books

These books are illustrate fun science projects, experiments, and more. Many of them are written for children and are clearly illustrated with step-by-step projects. Projects include how to make a metal detector from a calculator, make your own soda-pop rocket, and more.

- *Books: 50 dangerous things You should let your child do*
- Book: Geek Dad: Awesomely Geeky Projects and Activities for Dads and Kids to Share, by: Ken Denmead

Toys & games

These toys & games range from no-tech to high tech. We are critically analyzing each based on a set of criteria, including but not limited to: price, technology, goal-based vs. open-ended learning, and medium.

- Game: Crazy Machines
- Game: Reactiables
- Toy: LEGOs, LEGO Mindstorms
- Toy: LEGO: DesignByMe (application)
- Game: Crayon Physics
- Toy: Fisher Price, Smart Cycle Racer

Other resources and examples

- Generation M2: Media in the Lives of 8- to 18-Year-Olds. 2010. Henry J. Kaiser Family Foundation, Menlo Park, California.
- Heffernan, Virginia. The Attention Span Myth. Published in NYTimes on: November 19, 2010. http://www.nytimes.com/2010/11/21/magazine/21FOB-medium-t.html?_r=1
- Book: The Shallows: What the Internet is doing to our brains. by: Nicholas Carr
- Museum: Franklin Museum, Philadelphia, PA
- Museum: Please Touch Museum, Philadelphia, PA
- Paper: Towards Tangible Virtualities: Tangialities, *2002, Slavko Milekic, M.D., PhD, The University of the Arts, Philadelphia, USA*
- Make / DIY culture: Make Magazine, Make Philly, Maker Faire
- School: Project Interaction. http://projectinteraction.org/
- Place: Imagination Playground
- Facts about marketing to children. Donald F. Roberts, Ulla G. Foehr, Victoria Rideout,
- http://www.newdream.org/kids/facts.php
- NielsonWire. Kids in the U.S. Eyeing Big-Ticket Tech This Holiday Season. November 22, 2010. http://blog.nielsen.com/nielsenwire/consumer/kids-in-the-u-s-eyeing-big-ticket-tech-this-holiday-season/

MASTERS OF INDUSTRIAL DESIGN
THE UNIVERSITY OF THE ARTS