AC 2008-1387: GECKOMAN – AN INTERACTIVE GAME BASED ON THE PRINCIPALS OF NANOSCALE FORCES

Jacqueline Isaacs, Northeastern University
JACQUELINE A. ISAACS is an Associate Director at the Center for High-rate Nanomanufacturing (CHN) and an Associate Professor in the Department of Mechanical and Industrial Engineering at Northeastern University in Boston, MA. At the Northeastern location of CHN, she is responsible for education and outreach activities as well as research on societal implications. Her research focuses on economic and environmental assessment of manufacturing.

Jay Laird, Metaversal Studios
JAY LAIRD is Assistant Director of Game Design Programs at Northeastern University. He teaches multimedia courses and develops curricula for both the College of Arts and Sciences and the School of Professional and Continuing Studies. His research focuses on creating new forms of educational and social engagement through games. He is the Lead Game Designer at Metaversal Studios, a game company founded by NU alumni and faculty, which frequently collaborates on Northeastern University projects.

Lisa Regalla, Museum of Science Boston
LISA REGALLA is an Education Associate in Nanoscale Science and Engineering at the Museum of Science in Boston, MA. She develops and presents programs on a variety of nanoscale topics and acts as the liaison between the Museum and the NSF-sponsored Center for High-rate Nanomanufacturing (CHN) educational outreach initiative. She focuses on translating nanoscale topics for general audiences and bridging the gap between formal and informal science education.

Carol Barry, University of Massachusetts-Lowell
CAROL M. F. BARRY is an Associate Director for CHN and a Professor in the Department of Plastics Engineering at the University of Massachusetts Lowell, MA. She leads the education and outreach activities for the Center for High-rate Nanomanufacturing. Her research focuses on plastics processing, particularly at the micro and nanoscales and their application to high-rate nanomanufacturing.

Ahmed Busnaina, Northeastern University
AHMED BUSNAINA is the Director of the Center for High-rate Nanomanufacturing at Northeastern University, a collaborative Center among Northeastern, the University of Massachusetts in Lowell and the University of New Hampshire. He conceived the idea for the scientific basis of the game.

Geckoman – An Interactive Game Based on the Principles of Nanoscale Forces

Abstract

Funded by the National Science Foundation, the Center for High-rate Nanomanufacturing (CHN) (in collaboration with Metaversal Studios, a company specializing in educational games), has created an educational videogame targeted at children ages 10-14. The game, *Geckoman*, teaches scientific principles of nanotechnology and helps children differentiate between the nanoscale and the macroscale. The premise of *Geckoman* is that through an explosion of an incredible shrinking machine, budding scientist Harold is shrunk to the nanoscale. His lab partner, Nikki, helps him navigate three "worlds", beginning at the nanoscale and growing slightly larger until returning to normal size. Before exiting each level in all three "worlds", Harold must also pick up one of Nikki's notebook pages, which were scattered in the explosion. The notebook pages provide short tips and lessons that are mapped to national and Massachusetts state K-12 science and engineering standards.

1. Background and game description

An original videogame has been created, inspired by the popular "platformer" (*Mario Bros.)* and "beat-em-up" (*Streets of Rage*) game genres, designed to teach children ages 10-14 about principals of nanoscale science and engineering. The Center for High-rate Nanomanufacturing (CHN) began production on *Geckoman* in the summer of 2006, first creating a trailer and video walkthrough demonstration of gameplay prior to an NSF site visit. The enthusiastic reaction to the videos convinced CHN to use outreach funds to create a game that would make nanotechnology not only accessible for kids, but also engaging and fun.

In creating the game, the developers experimented with a variety of concepts, drawing inspiration from various traditional videogames and attempting to match them to important nanotechnology concepts. As a starting point for the science of the game, the team explored the relationship between the size of an object and its adhesion through van der Waals forces. Sketches for several different puzzle-type games were composed, but one idea quickly rose to the top as the most interesting and accessible route to this information. Geckos use a strong force at the nanoscale, van der Waals forces, to "stick" to surfaces and became the focus of the game.

World 1 (Fig.1) consists of nine levels in a setting of a Wild West town that is suspended, upside down, on the ceiling of Harold's lab (issues of fantasy vs. reality in science will be explored later in this paper). The player (Harold) advances through the levels by entering the "gold mines" at the end of each level. The main concept of World 1 is focused on van der Waals forces that allow nanoscale Harold to "defy gravity" and walk on the ceiling. If Harold's weight (from picking up too many items, for example) exceeds his adhesive force, it will cause him to fall from the ceiling and lose a "life". As with most action videogames, players are given multiple lives so that they can learn through trial and error; they can earn additional "lives" to prolong the game through various bonuses, which are designed to reward learning.

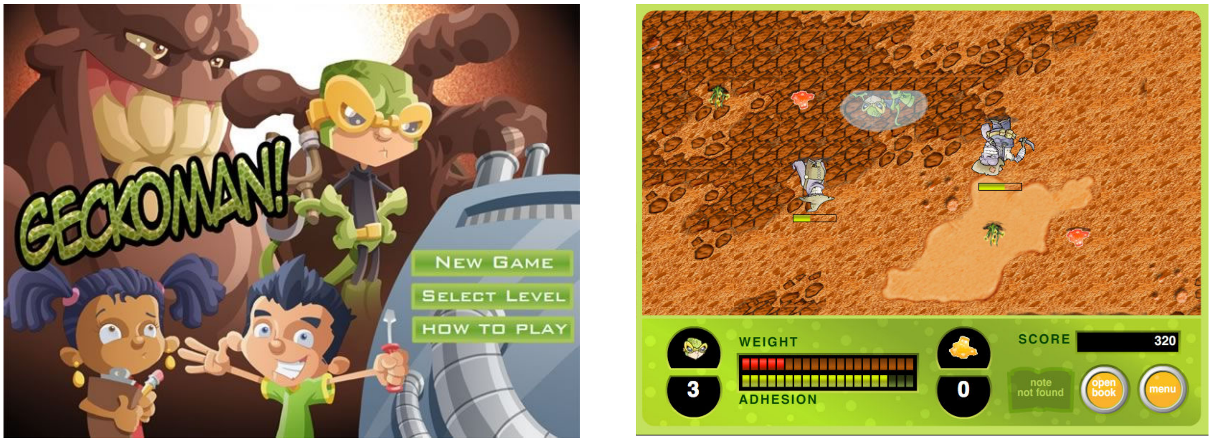

Figure 1 a & b: Screen prints of intro page and World 1 of the Geckoman computer game

World 1 also introduces the Nanoids, the tiny alien race who want to steal Harold's shrinking machine so that they can bring themselves to the macroscale. The Nanoids attack Harold by sticking nanoparticles to him and thus, increase his weight. However, Harold can fight back using the same technique and slingshot gold nanoparticles at the Nanoids in order to increase their weight. In World 1, the Nanoid characters all have an "adhesion" meter over their heads; when the adhesion drops to zero, the Nanoid falls off the ceiling. Harold (the player) has two meters: weight and adhesion. The meters visually emphasize when Harold's weight exceeds his adhesion, gravity is the dominant force, causing Harold to plummet to the floor.

In World 1, players also learn about the effects of surface area on adhesion and can crawl to increase contact with the surface and thus, increase adhesion. In addition, Harold can take advantage of the water "power-up" item, which is found scattered through the levels, to temporarily increase his adhesion. Finally, Harold can lure enemies onto rough surfaces, which decreases adhesion, making it easier for enemies (or Harold) to be pulled off the ceiling and fall.

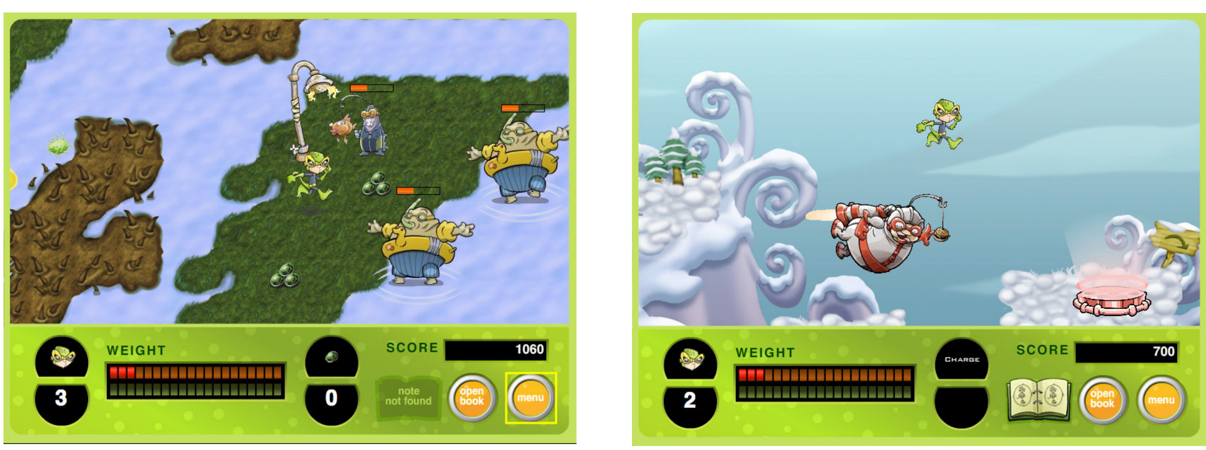

Figure 2 a & b: Depictions of Harold, as Geckoman, evading enemy assault in Worlds 2 and 3

In World 2 – a puddle on the laboratory floor shown in Fig.2a, Harold is still at the nanoscale, but somewhat larger, as the shrinking machine's effects have begun to wear off. As a result of his increased size, he is no longer under the grip of van der Waals forces, and he falls from the ceiling to the floor. Fortunately, a puddle on the floor (which at his scale appears to be a vast swamp), breaks his fall. World 2 consists of nine levels where surface tension and cohesive forces determine Harold's ability to walk on water as long as he does not obtain too much weight or exert enough downward force (through jumping) to break the surface tension of the water. The goal remains to find all of the notebook pages.

Enemies in World 2 have a weight meter, which increases as the enemies are hit (using the same mechanism as World 1, except the ammunition is now nano "dirt" instead of gold. When the enemy weight meter is high, gravity's effect exceeds the force of the water's surface tension, and the enemy sinks. Harold must also watch his weight to prevent his own demise. World 2 introduces two new concepts. First, the "electric shower" zaps away extra particles that have accumulated onto Harold by changing their electrostatic properties. Second is the "corkscrew tail", which enables Harold to zip through the water, much as some forms of bacteria do.

In World 3 (Fig. 2b), Harold has reached the microscale and can no longer stand on water, but he is small enough to be able to jump on floating dust particles. World 3 contains nine levels set in a microscale cloud world. The force of gravity becomes a more dominant force because of Harold's increased size and weight. The player, however, must now contend with electrically charged particles causing Geckoman to stick (if the charges are opposing) or repel (if the charges are opposite) to various objects and enemies. In this final world, the objective is to collect the missing pieces of the "shrinking machine" along with notebook pages that explain how to reassemble it as a "growing machine".

World 3 expands on the concept of electrostatic forces from World 2, giving Harold the power to change his charge between positive and negative by jumping through "electric clouds". The charged Harold can bounce off of objects that have the same charge as him, while he will stick to objects that have the opposite charge. World 3 also introduces microscale fasteners and contrasts them with nanoscale bonds. At the end of World 3, after Harold has beaten the Nanoids to the last piece of the machine, there is a final puzzle that requires the player to use knowledge about different fasteners to "build" the machine via a drag-and-drop interface.

2. Mapping science to game mechanics

After settling on the relationship between van der Waals forces, gravity and weight as the core of the game, the developers set out to map this metaphor to a familiar form of videogame play. Since many kids ages 10-14 play videogames regularly, the decision was partly based on the notion that a large portion of the target audience would enjoy the feeling of coming into the game with some level of mastery already established.

One of the pleasures of playing a videogame is discovering the "physics" of the game. In videogame parlance, "physics" often refers to the rules of the game, extending beyond normal physical simulations. Often the bizarre physics of a game lend it a magical quality. For example, in the *Mario* games, mushrooms enable characters to grow or shrink, and colliding with bricks yields coins instead of concussions. The pleasures that keep players coming back for each new *Mario* game include the discovery of the expansions or unexpected changes to the physics of the game, and the increased level of difficulty of the puzzles in subsequent games.

This is an idea that has not, until recently, been explored in much depth in educational game design. Many educational games use familiar videogame themes to encourage memorization of facts, but the student level of interest in such games is often low. Game critics refer to the production of such games as "chocolate covered broccoli," which is to say that students may find the game appealing at first (the chocolate), but as soon as they dig in, they find the "good for you" part all too easily (the broccoli). The challenge is to make children *want* to learn in order to complete the game rather than feeling "tricked" into learning information through gameplay.

A common motivational strategy in educational videogames is the "roadblock" – a barrier to game advancement that requires a specific piece of knowledge. In many games, such barriers are implemented as "skill and drill" exercises: students are expected to retrieve knowledge imparted earlier, often from sources outside the game. If a key piece of knowledge has not been acquired (either through the student's own careless study or due to an outside source's failure to communicate), the inability to pass a roadblock can cause a level of frustration that ultimately leads to the student losing interest in the game.

Geckoman attempts to bypass the "roadblock" motivational strategy by conveying the scientific principles throughout the game, while at the same time "testing" the students in the course of gameplay. In *Geckoman*, the information about scientific forces is conveyed primarily through the (literal) physics of the game. Just as a player of *Mario* games enjoys discovering new ways to make Mario jump, swim, duck, etc., players of *Geckoman* report enjoying learning the different ways that Geckoman can interact with his nanoscale world.

Players of *Geckoman* immediately realize that new rules must be learned as they witness their character, "Geckoman", walking upside-down on a ceiling. In fact, *Geckoman* is played upside-down in the entirety of World 1. Instead of a "health" meter, the player has a "weight" meter, which increases when the player picks up objects (intentionally or otherwise). The player must keep the "weight" meter below the value of the "adhesion" meter, which measures how well Harold is sticking to the ceiling (different parts of the ceiling have different adhesion values).

After the player is introduced to all of the power-ups and pitfalls of the inverted ceiling in World 1 through the first seven levels, two additional levels test and reward the player's knowledge through their gaming skills. Level 8 is a "reinforcement" level that offers a harder version of the puzzles found on previous levels, requiring the player to combine earlier information in new ways. Level 9 is a "boss" level, a standard element of "platformer" and "beat-em-up" games in which the player must defeat a single large villain. The same rules apply as on earlier levels, but the "boss" challenge is in some ways a reward to the player, as it represents the epic battle gamers expect. Each "boss" battle is followed by a "cut-scene", a short, non-interactive video that provides the transition between each world. The subsequent two worlds both follow this same pattern: seven levels of gradually increasing knowledge challenges, followed by a reinforcement level and a boss level.

At the conclusion of World 3, the final puzzle requires the player to "build" the machine via a drag-and-drop interface using different fasteners. This final puzzle tests the player's knowledge acquired from the third-world notebook pages. While it is possible to solve the puzzle without reading the notebook pages, it is significantly more difficult to do so; players are reminded by

Nikki to consult the notebook at the game's end. The purpose of this final puzzle is to reinforce the importance of the science notebook information and to encourage players to review the information presented throughout the game.

3. Adding standards-based science content

As the first draft of each game world was completed, the concepts introduced were compared against state and national science education standards. This was a challenge since nanotechnology is a relatively new field; the concepts have yet to be incorporated into the National Science Standards. Nanoscale science and engineering, however, draws upon many of the concepts present in traditional sciences such as chemistry, biology, physics and engineering. Based on evaluation of these standards and the game's characters, styling, and difficulty level, the team determined the target audience would be children ages 10-14. The science presented needed to be fine-tuned to match known expectations for content targeted for this age range.

Figure 3: Science hints from Nikki in World 1

Many of the complex concepts (such as van der Waals forces) introduced in *Geckoman* are taught at a high school science level or higher, so a need emerged to introduce some "lower level" science information for the target audience. The problem was how to test for understanding of this information in game play without creating a quiz-like "roadblock", while still ensuring that students read the science writing in the game.

The initial solution was to have Nikki, Harold's lab partner who helps him navigate through the strange game world, tell the player about the additional science concepts. At first, this additional information was conveyed through popup text windows (Fig.3), but early playtests showed that players did not like the frequent interruptions to gameplay in the introductory levels. The information was later moved to the lower right corner of the screen, but tests with students revealed that the text boxes were barely noticed. A voiceover was added for Nikki, providing audio reinforcement for the notes. More testers reported listening to the information and occasionally looking at the text display for reinforcement, but the information still felt "lost" to them. Most testers paid attention primarily to the gameplay tips – i.e., which keys to hit to perform certain actions – rather than to the science explanations.

The developers concluded that the best way to emphasize the importance of this new information would be the creation of a Science Notebook that would appear throughout the game. Each notebook page (one at each level of play) has a different learning objective. When Geckoman finds a page to the notebook, it opens to reveal a set of information presented through simple drawings, hand-printed font and a format based on actual science notebooks (hypotheses, experiments, conclusions). To maintain the playful sensibilities of the game, hypotheses are called “Harold’s Hunches”, while explanations are “Nikki’s Notes”. Players are required to find the notebook page on each level before advancing to the next one. The collection of the notebook pages (Fig. 4) is now a major goal of the game, as Geckoman cannot return to normal size without all of the facts that will help him to rebuild his size-changing machine.

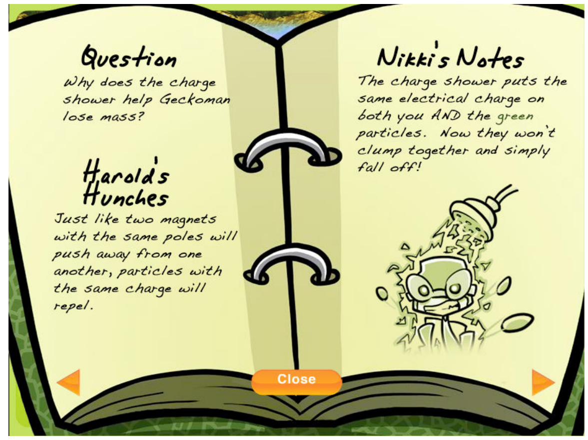

Figure 4: Sample notebook page

Initial informal testing of the game through a closed alpha test revealed that most people did not stop to read the notebook pages when they first appeared, until later when they realized their significance. In response, a “read notebook” button was added to the game interface, giving the players an easy way to pause the game and browse the pages they collected. Players reported more often seeking out the information in the notebook later, once they realized it might give them assistance with gameplay. The addition of the end-of-game puzzle, which requires the notebook to solve, also reinforces the need to review notes, and, will convince players to spend some time reading the notebook pages.

To introduce the concepts gradually through gameplay and notebook pages, the team began to work with the Museum of Science, Boston, on writing the text to address each notebook learning objective. Up until this point, the game’s challenges had been structured in the order that made most sense for a typical arcade game. With the new standards-based content, a way of introducing the material in a sensible order became more important. The team dissected the contents of all 27 levels of the game, reordering the introduction of various game elements to coincide with lessons taught through Nikki’s guidance and through the notebook pages.

In working with the Museum of Science, the team discovered more possibilities not only for science learning in the game, but also for science-based features that would make the game more fun. For example, in World 1, the player can create gold piles and drop them off the ceiling. The reward for collecting gold instead of using it as a weapon against the Nanoids is an extra life. In the first version of the game, the gold particles were depicted as “gold” colored. The Museum of Science team, however, pointed out that gold at the nanoscale is not in fact gold-colored, but can be many colors including red and blue depending on the size of the particle. A minor change in the game’s programming allowed the gold’s color to shift depending on the quantity of particles in the pile. When the gold actually turns “gold” in color, the player receives visual feedback that he is about to create a gold pile sufficiently large enough to earn points.

By writing the new notebook pages about strange phenomena, like the gold color change, the team hoped to provide material that students would actually want to read to gain a better sense of the game world. While the team worked to maintain the “sweet spot” between learning and play in the game, they showed some of their science writing to K-12 teachers involved with various programs at Northeastern University. The feedback indicated that teachers desired more information on the subject of nanotechnology if they were to assign the game to their students.

By releasing *Geckoman* as an informal science education tool, the hope is that children will play the game for sheer enjoyment, and perhaps go to their parents, after school program instructor or science teacher with questions. To prepare instructors for this opportunity, work has begun on a guided manual to accompany the game. The goal is not to get teachers to adopt *Geckoman* as a classroom lesson, but to encourage educators of all kinds to use the game as a "teachable moment" to introduce children to this new field of nanotechnology.

4. Iterative refinements

In June 2007, *Geckoman* was tested by members of the Museum of Science team, including educators and the thirteen-year-old son of an educator at the museum. The game was overall well received, but there were still concerns about matching the game to the target audience, especially in areas of diversity and accessibility.

In early iterations of the game development, players alternated between playing Harold and Nikki, working out puzzles that involved making the characters cooperate. This added an additional layer of puzzle complexity to the game that distracted from the science learning. The team felt that it was important to provide both female and male characters, and a debate ensued over whether additional time and money should be spent giving the players a choice of character, to ensure audience identification across the broadest possible audience. Ultimately, given the budget and time constraints of the original six-month development plan, it was decided to make Harold the brawn and Nikki the brains.

Nikki originally had been named Nancy, and both characters were white and appeared as middle-class, stereotypical "science nerds." The team felt that this might limit the appeal of the game for some of the target audience, and that the "science nerd" stereotype needed to be avoided to make enjoyment of science more accessible to the target audience. The team decided that Nancy should be made more ethnically ambiguous; the character was redrawn, her name was changed, and a new voice artist was sought. Fortunately, since Harold spends most of the game in his Geckoman superhero costume, only the game's initial and final cut-scenes (storytelling scenes shown before and after victory on each world) had to be revised to "de-nerdify" Harold.

The language of the game was revisited, with a careful eye for balancing slang that would appeal to a youthful audience with words that might be difficult for students for whom English is not their first language. Explanations were limited to three sentences, to ensure that it would not require too much reading time to digest. The majority of the knowledge acquisition still occurs through gameplay and experimentation: learning by failing, or in the case of World 1, by falling.

5. Playtesting and informal assessment

In July 2007, *Geckoman* underwent its first playtest with a group of 7th and 8th grade students in the Harris Camp program. For this playtest, the game developer and chemistry teacher worked together to lead 20 students through the worlds of *Geckoman*. Students were given no information about the game in advance, other than it was about nanotechnology to ensure that the learning demonstrated was from the game itself. Because so much of the core knowledge of the game is intrinsic to gameplay, it was difficult to develop a formal test for the students to qualitatively determine how much they learned. Instead, the team had the students play the game for fifteen minutes and then asked them to take a break to discuss what they learned.

Through discussion, the students demonstrated that they not only had an understanding about the weight-adhesion relationship that is at the core of the gameplay, but also knew the appropriate vocabulary. They, however, did not develop the vocabulary that was only referred to in the notebook pages; these often were collected by students but went unread. As with earlier informal testing, students generally paid more attention to Nikki's voiceovers; the text cues that did not have voiceovers were most often ignored, since they no longer required the player to dismiss them from the screen.

At the end of the playtest, students were asked to answer some questions about their experiences, which are reproduced here:

1. What is going on in World 1?
2. What is going on in World 2?
3. What is going on in World 3?
4. What did you like most about the game?
5. What would you like to see added?
6. Did you read the instructions?
7. Did you read Nikki's help screens?
8. Did you read the notebook pages?
9. Anything else?

For the most part, students reacted positively to game play and offered their critiques and suggestions for improvement. Comments included:

"In World 1, we learned that to stick to something you have to have enough adhesion and not a lot of mass." (7th grader)

"In World 3, we learned that if you have the same charge, it pushes away" (7th grader)

"I think the game should have some hints for each world." (8th grader)

"In World 1, they're trying to stick to the ceiling, and if they pick up too much gold, it adds to their mass and they fall." (8th grader)

"I would like more explanations! World 2 was really hard because the water things shoot too fast and they can't get out of the way. I would also like Worlds 2 & 3 to be easier." (8th grader)

"I think that the science should be more involved in the game because people could just skip reading notebook pages and not learn much. Overall, I really liked the game good job :)."

In October 2007 (with significant revisions based on player comments, including a rework of the notebook and Nikki dialogues to make them more noticeable by players), *Geckoman* underwent a second playtest, with another group of 7th and 8th grade students from the Explorations program, a one-day program for selected Boston and Cambridge public middle schools, sponsored by the Harvard Medical School Office for Diversity and Community Partnership, the Minority Faculty Development Program/ K-12 Programs, the Biomedical Science Careers Program, and the Boston Science Partnership. As part of the Boston Science Partnership, Northeastern University and the University of Massachusetts Boston offer lab visits to students from selected schools. Similar comments were offered by these students after gameplay. This time, more students reported reading Nikki's dialog since it paused the game until they dismissed it from the screen. This action also cued some students that the notebook pages might be more important; more student were observed at least spending a moment on each page instead of immediately clicking to advance.

Based on the comments from these two playtests, the game was further refined and presented to the Nanoscale Informal Science Education Network in November, 2007. The National Science Foundation awarded $20 million to fund the national NISE Network (NISENet), which will develop interactive exhibits to teach the public about nanotechnology. The network's goal is to have these exhibits in 100 museums across the United States in the next five years. Representatives from schools and science museums greeted the game with enthusiasm, made further suggestions for refinement (including translation into Spanish), and offered to help with the beta testing. The museums and educational institutions involved in the NISENet are interested in using the game and have been asked to help with the final phase of dissemination and assessment.

A third playtest, this time with 5th and 6th graders, was conducted in February, 2008, again in closed beta, but this was the first test with students at the younger side of the game's targeted age range. The results were overwhelmingly positive. The 5th graders especially enjoyed the game, some going so far as to call it "the best videogame ever." Both 5th and 6th graders demonstrated no difficulty understanding the game's concepts.

For this third playtest, students were divided into two groups, one that played the game first, and one that participated in a hands-on science lab first. The science lab involved changing the color of gold by affecting the particle density, just as occurs in the *Geckoman* game. The students who participated in the science lab first immediately saw the connection between the gold in the game and the gold from the science lab. Students who participated in the game first more quickly were able to describe what was going on in the science lab.

Although none of these playtests have involved a formal "testing" element, a key fact that has emerged is that students understand the difference between the fantasy and real science elements of the game. Students all understand that there is no shrinking machine, nor tiny aliens living on their ceilings, but they also understand that at the nanoscale one can defy gravity and gold can change colors. The game provides a means of relating the "magic" of the videogame world to seemingly magical real-world forces.

6. Plans for launch and assessment

As of March 2008, the team is completing the final revisions to the game's features and science content. With each feature change, new science content is inspired, and with each new piece of scientific information, new features are inspired. The result is a game on which development could continue forever, but the hope is to enter a public beta-testing phase. On March 30, 2008, Geckoman will be demonstrated at the Museum of Science, Boston, during the first weekend of "NanoDays", which was created by NISENet to provide a time and way to get community-based educational outreach efforts focused on nanoscale science, technology and engineering. The computer game will be freely distributed (upon its completion) to interested teachers and players via several web sites, including the National Center for Teaching and Learning, the Nanotechnology Informal Science Education Network, and web sites for gamers. Dissemination is also expected through our RET (Research Experiences for Teachers) network and by publication through the National Science Teachers Association.

A more formal assessment of the game, based on student achievement of learning objectives, is planned prior to promotion as a teaching tool for educators. Grant funds permitting, the next phase of testing will involve creation online assessment tools. The goal is to use as much passive tracking as possible in order to keep from "breaking the spell" and making kids realize they are learning. In game design terminology, this is sometimes referred to as keeping within the "magic circle" of the game. While there may be a pre-test and post-test attached to the next version of the game, all testing would be through achievements within the game itself.

To assess learning remotely, the amount of time spent looking at each notebook page versus the amount of time needed to complete each level would need to be tracked. This would indicate whether the notebook pages assist with game play. By looking at the amount of time spent on each level of the game, the team would be able to assess how quickly students climb the "learning curve" for each section of the game. Of course, one must also take into account varying levels of hand-eye coordination, but the game levels have been iteratively refined to produce a smooth increase in the level of physical skill required to beat the game.

With the standards-based science writing within the game completed, a teacher's manual to accompany the game is desirable to provide expanded versions of the information included in the game's science notebook, as well as assignments based on the science that students can complete as a classroom activity. The teacher's manual would include suggested means for assessing student learning and could also be disseminated through the NISE Network, with the condition that teachers report back on student progress before and after game play.

A "limited" version of the game is planned as an exhibit to science museums. The idea of the limited game is to provide a short three to five minute experience for players, to keep visitors moving through the museum exhibits. The end of the limited game will be a promotion for the full game, which will be made available freely online, likely through ad-revenue-producing sites such as Shockwave.com and Kongregate.com. Through this type of videogame, it is hoped children will be interested in exploring and learning about scientific concepts that depict the differences between the nanoscale and macroscale.

Acknowledgements

The authors would like to acknowledge the support from the Nanoscale Science and Engineering Center for High-rate Nanomanufacturing at Northeastern University as part of their education and outreach cost sharing funds to develop this game. Funding from the National Science Foundation Award EEC-0425826 supports this Center. The authors are grateful to all of our play testers (young and old) who have dedicated time and offered comments to improve the educational and entertainment quality of this game.