MIT GAMES-TO-TEACH PROJECT

Design Document for:

DREAMHAUS

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Version # 1.01

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Versions

Version 1.0
Previous Documents Assembled by Kurt. Made some additions:

- Tables of time / user experience
- Added pedagogical notes
- Tweaked some language to place more of the curricular burden on teachers
- Added comments/ notes for the group to look at.

Version 1.01
Kurt Squire, February 2002

- Added Zach's Writing
- Added Characters
- Wrote Scenario from Character's perspective
- Added Visuals

Version 1.02
Kurt Squire, February 2002. Added

- Table of Contents
- Assessments
- Pedagogy
- Academic References

Reformatted Document and proofread.

Still Missing: (Wally)

– Examples of puzzle/ Scenario written from "player's perspective" e.g. player looks around the corner, decides to explore this hallways, feels X, reacts Y, etc.

Version 1.02
Proofread by Cynthia Jenkins, March, 2, 2002.

DREAMHAUS

"The fate of the world is in the hands of one beautiful girl." (1984 Mattel promotional slogan for new Barbie, She-Ra Princess of Power)

The problem of our epoch is *the problem of the house Le Corbusier (1919)*

DreamHaus is a third person adventure / design game. The player, Bobbi, is a successful architect striving for acclaim as the world's first woman to win the prestigious AIA Gold Medal. *DreamHaus* uses architecture as an entry point for learning AP-level mathematics, engineering, and physics material. Players examine virtual architectural sites (such as the Tokyo Olympic Stadium), solve physics and engineering-based puzzles, and complete architectural design challenges using the game's design tools. Players may also participate in a web-based community surrounding the game, submitting their designs, viewing others' work, or offering critique on designs.

DreamHaus draws on the artistic allure of architecture and romantic history to make physics accessible to those typically not interested in Physics, Mathematics, or Engineering. Further, the game uses the exploration of fantastic virtual spaces, thought-provoking puzzles, the systemic nature of structural engineering, and opportunities for creative expression in virtual communities proven to be successful with non-gamers in Myst and The Sims. Further, *DreamHaus* is grounded in David Perkins' *Teaching for Understanding* a pedagogical framework that is designed to foster deep, intuitive understandings of phenomena by providing learners multiple entry paths into understanding and performance-based modes of expression.

Rationale

As feminists, we chose to base our main character, Bobbi, on the doll, Barbie. This allows us to explore a feminist theme within the game: Bobbi is a woman who has transcended society's limited notions about who she is and what she can do. Once a mere plaything, Bobbi is now a formidable player in the high-powered world of architecture and design. The wink-wink reference to Barbie draws players into the game through an implicit critique of the Barbie brand, which is known for engendering attitudes of learned helplessness in females toward math and science. The implicit critique of Barbie and sassy, camp aesthetic *DreamHaus* employs provide potential paths of resonance for a sophisticated, media-savvy demographic that is coming to terms with gender roles and value wry sarcastic humor. Similar approaches have been tried recently with great critical and commercial success in properties like *Buffy the Vampire Slayer* and *Legally Blonde* (See game philosophy). Of course, players are free to solve the physics-based puzzles and tackle the architectural engineering design challenges without necessarily appreciating the critical sub-text running through the game.

Backstory

Bobbi at one time was a Malibu resident with her boyfriend Kevin, leading a rather shallow, passive life. At the age of 35 she has an epiphany and decides that she has always felt like a doll living in a dollhouse. She goes to architecture school to become an active creator of buildings rather than a passive inhabitant of life. Architecture School is a transformative experience and Bobbi becomes a world class architect.

The Setting

When the game opens, Bobbi is a 50- something, cutting-edge architect in Soho with an asymmetrical haircut. Other main characters include Kevin - (previously Ken) now Bobbi's harried, gay assistant, and Skipper - Bobbi's smart-alec intern. Also recurring will be "The Money" a disembodied voice that communicates Bobbi's assignments through her super-powered PDA. The Money's character is meant to be reminiscent of 007's superior Money Penny. The player will control only Bobbi; all other characters will be controlled by the game and will present the player with constant challenges and clues.

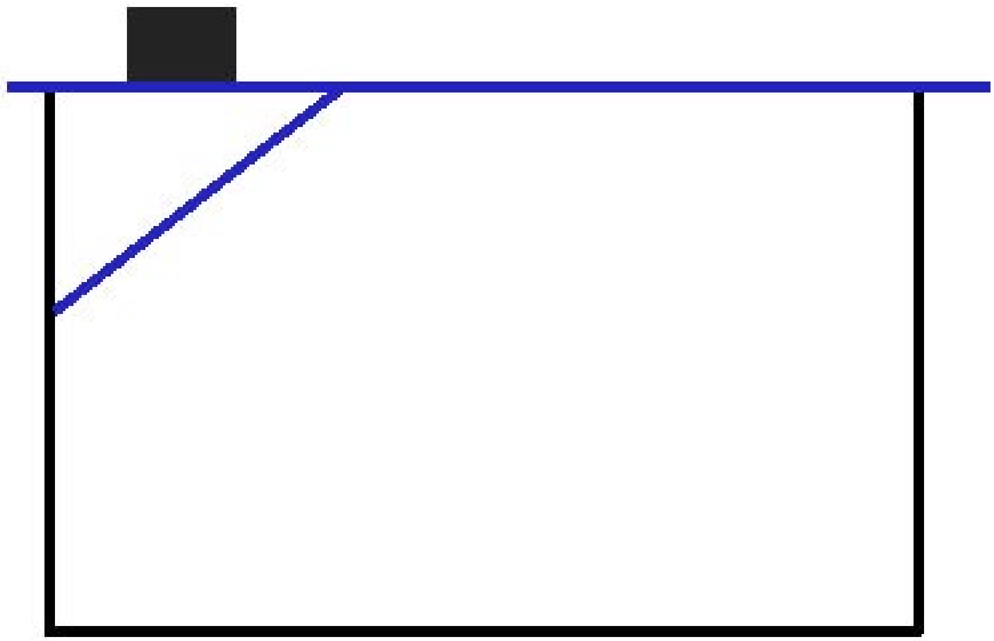
While at the top of her game professionally, one major prize has eluded Bobbi's manicured grasp: the AIA Gold Medal Award. The gold medal is the profession's highest honor. No woman has ever won it. That's where the player steps in.

Gameplay

Playing as Bobbi, the player visits architecturally significant buildings, solves puzzles to unlock the mysteries of each building, converses with the ghosts of (or living) architects, researches information in texts and on the web, and designs buildings.

To win the Gold, each architect must fulfil seven design challenges. Each one is harder than the last and targets a specific set of physics and engineering concepts or principles. For help, Bobbi turns to her crackerjack intern, Skipper. Skipper suggests a field trip to a historical building where they might unearth the secret of the current challenge. Using Bobbi's futuristic cell phone, they travel through space to the building. There, they are greeted by the ghost of the architect who gives them clues about the design secret (a.k.a. the target physics concept).

At the architecture site, the ghost leads the player through a series of game puzzles designed to communicate specific physics/ engineering / math concepts. These puzzles are embedded in the physical game space, but often focus the player on specific elements of a design. For example, in the first level, the player completes a simple puzzle trying to stack as much weight as possible on to simple beam support structures made of stone and wood. In later puzzles players explore the physical properties of the arch by putting together egg puzzles. The series of puzzles are designed to develop students' understandings in a manner similar to a tutorial. They are sequenced so that students encounter a variety of examples embodying the concept.



Once the player has completed the series of design challenges, she is given a full explanation of the concept. Consistent with guided discovery pedagogical techniques, this revelation coincides with the player's discovery of the secret behind the design challenge. Next, she returns to her office and works on a design incorporating the target principle or concept using the CAD element of the software. Bobbi can import each of the buildings she visits into the cad software as well. When she is done, she submits her work to the architectural engineer (the CAD Software), who tests it for it for obvious structural problems before she submits it to the AIA panel. The architectural engineer features artificial intelligence technology similar to that found in *Bridge Builder*, Digital Canal's *Structural Engineering Frame Analysis*, *StrucPro*, or *STRAAD* Analysis. This analysis highlights areas of high stress so that the player can identify weak areas in the design.

Once Bobbi's design passes through the architectural engineer's review, she can submit it to the AIA panel. Depending on the particular learning context, the panel may be a teacher, a panel of peer reviewers, a panel of community experts designated by the teacher, or a panel assembled from the *DreamHaus* website. The panel reviews the design, and decides if Bobbi has met the design challenge. If she has, the panel presents the final challenge. If she has not, she can return to the site-based tutorials with the ghost of the Architect, additional advice from the Architectural Engineer, and more support from Skipper in the design phase.

When Bobbi has successfully reached the 7th design challenge, the AIA panel throws her a curve. They ask her to design her own *Dreamhouse* to her own specifications. The only catch is that the design must incorporate all 6 of the previous physics concepts. The field trip leg of this trip is an historical and cross-cultural tour of domestic buildings from castles to tenements. Bobbi can use the trip as inspiration to design a home that suits her own history, needs and dreams. Of course, since Bobbi is the player, the end product is a construction that reflects the player's personality. The panel will only award Bobbi the AIA Gold Medal Prize if each of the 6 target concepts is correctly employed on the first submission of the design to the panel.

Controls

Controls in the office place and in the virtual tour are very simple – point and click to where you want the character to go. Left mouse moves you there; right mouse lets you interact with the object, if that's possible. Players can communicate with other players, objects, or the ghosts of architects.

The CAD software would also be a streamlined version of commercially available CAD software. The idea would be to present less functionality, simpler capacity to build simple objects (e.g. pre-rendered shapes).

Game Philosophy

A game for non-gamers? Physics for humanists?
As game designers, we dreamed up a game about Physics that would intrigue Humanists. We strove to include narrative features missing in many games: Rich characterization, witty dialogue, realistically-drawn figures from history, and complex interpersonal relationships – design elements that are known to appeal to diverse audiences (See Cassell & Jenkins, 1998).

Many non-scientists studying science ask: When will I ever have to use this knowledge? *DreamHaus* presents students with a compelling way to apply and expand their physics knowledge for an imaginative and creative purpose: The design of innovative buildings. This game also addresses a growing concern in engineering education that students are graduating without the ability to synthesize material or think creatively with physics and engineering concepts (Sheperdson, 1999).

Why Barbie?
Bobbi's *DreamHaus* is an adventure/puzzle game with an attitude. It employs a direct parody of Barbie and the Barbie aesthetic in order to attract a segment of the population that both computer games and science have long neglected: girls and boys more literary than scientific more comfortable in character-driven, real-life spaces than fantastical ones. The Barbie reference is a loaded one and some may misinterpret a parody as a "dumbing-down" rather than a sophistication. We believe that by going straight to the heart of the gender debate we will attract a much desired demographic to the gaming community: a group of young adults known to resist pedagogy that comes across as didactic or patronizing. By exploiting one of the central icons of our culture in an entertaining, humorous way, we will take game narrative to a new level and draw an important population into the world of science.

Barbie has had a long and highly visible history with girls and games. While *DreamHaus* is not specifically designed for women, women are well-represented in one of our target groups: non-gamers and those who see themselves as non-scientists. Our choice of a Barbie reference was informed both by a sense of the marketing potential and the opportunity to be provocative with ideas about feminism and gender.

The most successful game for girls ever produced was a game based on Barbie. While feminists have decried the sexist ideology long associated with Barbie, we take a more complex and broader view of the Barbie phenomenon. Mattel may market Barbie with implicitly or explicitly sexist advertising, but children have always made Barbie their own through highly individual play and story-making. We believe that the genius of Barbie is that she can absorb a multitude of identities, attitudes, and play patterns. This quality is what has made her such a tried-and-true choice for make-believe. Had Barbie less ideological flexibility, she would never have exhibited such staying power for so many generations of highly individual girls (and their brothers).

As feminists, we have made Barbie our own too- projecting on to her a vision of a driven, talented woman who is not a slave to the idea that a woman must always be nice in order to be good. As a complex, sharp-witted character, Bobbi will appeal to our late-adolescent players who are actively working out their own identities in response to cultural pressures.

We anticipate that some feminists may not see beyond the Barbie reference in our game and that the game may be the source of some controversy and contention within the feminist mainstream community. We welcome such attention to the game and the issues it plays with. *DreamHaus* is consciously pushing the envelope about science education, games for females and non-gamers in general and feminism itself.

Pedagogical Approach

Our pedagogical approach builds on constructivist approaches to instruction, where game players learn physics and engineering concepts through:

- Guided Discovery of physics and engineering concepts embedded in architectural design;
- Manipulating digital tools in order to “play” with the concepts behind civil and architectural engineering;
- Designing buildings embodying their understandings of physics and engineering concepts in a problem-based learning framework.

DreamHaus specifically addresses findings in cognitive science research highlighting that students:

- In traditional learning environments fail to develop intuitive understandings of scientific concepts (e.g. Bransford et al., 1977; Gardner, 1994).
- Retain naïve understandings of physical and engineering phenomena (e.g. Gardner, 1994; Sheperdson, 1999).
- Can overcome such alternative conceptions of physical through the design and modeling of 3D worlds (e.g. Barab, Hay, & Barnett; Perkins, 1986).
- Can build deeper understandings of phenomena by accessing information via multiple channels and representing multiple modes of understanding (e.g. Gardner, 1999; Perkins & Unger, 1999).

One key principle behind contemporary science education research is that students benefit from opportunities to tackle fewer concepts but in greater depth. Building on David Perkins’ research into teaching for understanding, *DreamHaus* provides students opportunities to perform a variety of thought-demanding things with a topic—like explaining, finding evidence and examples, generalizing, applying, analogizing, and representing ideas in a new way.

One metaphor for thinking about how physics and engineering can be learned through the study of architecture is through the role of the Architectural Engineer. Architectural Engineers review blueprints for factors such as structural soundness, electrical engineering systems, ventilation systems, and heating and cooling systems. *DreamHaus* sits in the nexus between these two fields.

Educational Objectives

The game strives to give players qualitative understandings of physics phenomena (Forbus, 2001). This game gives players opportunities to:

- Develop intuitive understandings of physics and engineering concepts and principles.
- Identify how physics and engineering concepts and principles are used in buildings of architectural significance.
- Develop and apply understandings of physics and engineering concepts and principles through the design of architecture.
- Express themselves creatively through the design.
- Critique and evaluate the scientific quality of one another's designs.

Each task is designed to elicit a performance of understanding-not merely a cue to recognize formulas and concepts. Players will be presented with animations of each concept and graphical displays of phenomena embodying each concept. Design tasks demand that they mobilize these concepts in the design of buildings.

Target Audience

We present *DreamHaus*, an adventure/ puzzle / constructionist game designed for students years 18 and over studying AP and introductory college physics and engineering. *DreamHaus* is particularly geared toward students for whom science does not come naturally.

A fun, educational video game that addresses the needs of diverse learners by providing the player with multiple ways of working with key science and engineering concepts would have real educational value and appeal to this market. Our game takes an interdisciplinary approach to science and engineering, and focuses on key concepts at an introductory level that are often shared across these disciplines.

GamePlay

Gaming Objectives:
Narrative objectives. Making up for lost time is a big theme with Bobbi, In the 15 years since she left Malibu for Taliesin Architecture School, she has scaled every architectural achievement except the field's highest honor: the AIA Gold Medal Award which has never been awarded to a woman. Bobbi is driven to go for the gold this year by her own personal ambition AND ALSO her worsening financial situation.

Level Objectives. The AIA panel have decided that to win the Gold medal, contestants will have to perform 7 Herculean design challenges.

- "Tiny" Summer Home for The Money in Siberia.
- A stone house for a wealthy teenage actor whose parents are concerned that he needs a solid roof over his head.
- A home at least 35 stories tall for a short, wealthy businessman with a Napoleonic complex.
- A portable home of 30,000 square feet for a veteran circus performer who can't give up life under the big top.
- An Egg shaped home for an LA starlet who wants to live in a state of gestation and hopes the shape will protect her from earthquakes.
- Build an Antarctica resort for a east-cost, west cost rap star who is looking to chill out South.
- An underwater research facility for a shampoo company that wants access to an unlimited supply of salt water.

7 Steps to the Gold; 7 Levels of *DreamHaus*

Level	Design Challenge	Field Trips	Content
Tutorial	Design a small summer home in the Siberia from natural materials.	Dogon Home Irish Home Villa Savoye	Force; Beams; Loads; Equilibrium; Wood
1	Give wealthy child actor a solid "roof" over their head. Build a stone building with columns.	Pyramids Parthenon; Stonehenge	Force, Beams, Loads, Equilibrium; Stone.
2	Create a tall building for a little king.	Hancock Building Eiffel tower	Loads; Force; Trusses, Steel, Wind / side pressures; Tension and Compression; Shearing
3	Circus Tent	Tokyo Olympic Stadium; Nervi's airplane hangars; Super Dome	Tension; Elasticity; Rope; Cable; and Fabrics; Domes; Air
4	Earthquake Resistant Structure	Coliseum Pantheon Notre Dame Egg Church	Arches; Curved surfaces; Tension Force; meridians; Volume of 3D Space
5	Design a building for rap star to chill in Antarctica that won't melt or something.	Igloo; Ice Hotel	Wind, dome structures, Thermodynamics laws
6	Underwater Shampoo Factory	Geodesic Domes; Falling Water	Canterleavering
7	Bobbi's DREAMHOUSE	All previous sites	Open-ended

Notes on Levels

Images and historical background on all buildings can be found at http://greatbuildings.com. They also have images that can be used as research art, for a fee. They have free 3D models of many of the buildings as well.

Tutorial

Build a small summer home with natural materials available at the site. (The money doesn't want to invest any money in your project until he's sure that Bobbi can deliver). The player goes on a series of field trips of historical sites to learn the basics behind forces, loads, equilibrium, and the basic properties of wood and stone. The player visits a variety of simple, non-intimidating structures (Dogon Home, Irish Home, Villa Savoye) that are designed to draw the player into the world of design. They're all quite cute. Architecturally, this level focuses the player on the relationships between a structure and its environment, the needs of a single-family occupancy, and historical approaches to home building. From an engineering perspective, it allows the player to learn the properties of some basic materials (clay, mud, straw, wood), and design issues (beams, loads, gravity, and roofing).

Level 1

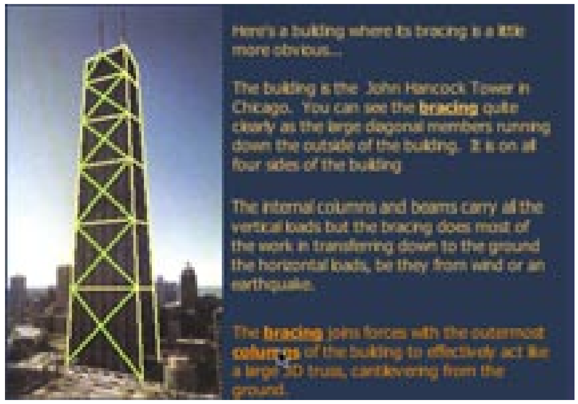
Give wealthy child actor a solid "roof" over their head. Build a stone building with columns. This level asks the question: how do such large structures made of heavily materials such as stone stand? The player begins by visiting the Pyramids and learning more about the geometry and physical properties of the pyramid (see Salvadori, p. 35-37). There, the player completes puzzles building pyramids, exploring pyramids of different dimensions, how the pyramids interact with the environment (e.g. wind) and running water over the base of pyramids. Completing the puzzles unlocks the mysteries of the pyramid. The player can now see force exerted on each block and the load baring of the structure.

Next, the player goes to Stonehenge, and examines the building's beam systems. Through this series of puzzles the player learns about Beam Control – "the principle of deflection and moment control by the use of adaptive applied end moments." Much of the basic science behind beams, etc. can be found at the initial tutorials at: http://moment.mit.edu. This site provides all of the basic information that would be needed to construct puzzles. Chapters 1-5 of Why Buildings Stand Up: The Strength of Architecture by Mario Salvadori is another good source for this material. The diagrams in this book suggest possible animations and puzzle games.

Finally, the player travels to the Parthenon. This level also allows for links to the Golden Proportion (see below). Including such material is critical for building a bridge between engineering and architecture. From greatbhuildings.com: "Even from the time of the Greeks, a rectangle whose sides are in the "golden proportion" (1: 1.618 which is the same as 0.618: 1) has been known since it occurs naturally in some of the proportions of the Five Platonic Solids. The Acropolis, in the center of Athens, is an outcrop of rock that dominates this ancient city. Its most famous monument, now largely ruined, is the Parthenon, a temple to the goddess "Athena" built around 430 or 440 BC. Though no original plans of the temple exist, it appears that the temple was built on a square-root-of-5 rectangle, that is, it is 5 times as long as it is wide. These are also the dimensions of the longest side view of the temple. The front elevation is built on a Golden Rectangle, that is, it is Phi times as wide as it is tall." Using the Golden Rectangle is one example of how DreamHaus uses architectural engineering – the intersection of mathematics, physics, and aesthetics to provide a compelling context for learning engineering.

Level 2

Create a tall building for a little king. Here the player learns about the properties of steel, bracing, and joists. This level requires more consideration of wind. Joints and bracing also become critical. The player goes through a series of tutorials similar to those found at http://moment.mit.edu/imageLibrary/contents/joints.html, where the player discovers the complex physical relationships behind the behavior of joints. Among other puzzles, the player in this level removes structural supports from buildings until the crumble under a variety of conditions (no wind, high winds, higher gravity).



Level 3

The player designs a Circus Tent for a former circus performer that spans 20,000 square feet. The player begins by visiting the Tokyo Olympic Stadium where he / she solves a variety of puzzles involving- torque (=rotational force). In one, the player plays with a trapeze artist moves from a sitting position to swinging by her knees; in another a spinning ice skater pulls in her arms--rotational inertia/angular momentum/velocity

Next, the player visits the Nervi airplane hangars. Engineer and architect Pier Luigi Nervi (1891-1979) was one of the more innovative builders of the 20th century. Most of his structures were built of reinforced concrete, either prefabricated or cast on site. Nervi believed that designers could solve construction problems by understanding the physical laws that regulate the equilibrium of forces and the resistance of materials. "His work as a theorist attracted a wide following. Through his designs, Nervi successfully made reinforced concrete the main structural material of the day. He was awarded Gold Medals by the RIBA, the AIA and the Academi d'Architecture. In the years 1946-61 he was a professor of engineering at Rome University."

Finally, the player visits the Superdome. These puzzles involve how air pressure can be used to create structure and the volume of 3D space. After completing the puzzles, she can play with an interactive Superdome where the player can manipulate variables of air pressure, materials, and size to see their effects on the SuperDome (See also Salvadori p. 273-274).

Level 4

Use the properties of curved surfaces to create an earthquake resistant structure. In level 4, the player first formally encounters curved surfaces. The buildings increase in complexity from simple arches to the final egg building, which has virtually no planar surfaces. Through these field trips, players encounter the physical properties of the arch, meridians, and revisit tension and volume of 3D space through visiting the Coliseum (arches), the Cathedral of Notre Dame (arches, buttresses), and the Egg Church. A walk through for portions of Level 4 is provided in the Appendix. Sliced egg on a Tutonic

Plate provides a nice introduction.
http://loohooloo.mit.edu/plan/plan_issues/50/egg/article_bottom.html.

Level 5:

The player designs an energy efficient structure made of ice that will let Snoop Doggy Dog "chill" while not freezing. Level five features a visit to a basic igloo, as well as the Ice Hotel, which is in Sweden. The bulk of the content is on thermodynamics, but the player also revisits dome structures, while also learning more about wind on these structures. There is an outstanding curriculum for understanding the math behind igloos at: http://www.mty.itesm.mx/decic/deptos/f/fisica/Dibujos/Igloo.pdf

Level 6:

Design an underwater building (2000 feet deep) of 2000 square feet and 40,000 cubic feet. Part of this challenge is that the player needs to understand both vertical and horizontal loads as underwater structures are under tremendous pressure from both the weight of the water and the force generated by currents. In order to understand some of the properties of water the player visits Falling Water, which uses a variety of engineering techniques, including canterleavering. From the Falling Water website:

> Thus Fallingwater utilizes and combines three kinds of cantilevering: extension from an anchorage (as in the iron arm suspending a kettle over the living room firegrate); counterbalancing (like simple scales); and loaded extension that permits limited anchorage (the way that a man squatting, with only the balls of his feet and toes touching the earth, extends his knees). Another unobvious aspect of the construction is that each floor level has its own support system. The main level is carried on four inconspicuous stub walls rising at the edge of the streambed; the slab extends far beyond them. The next level is supported from a central square of reinforced concrete beams, with corners resting on stone masses; from this square the second slab or tray, is cantilevered. The narrow top level is set along the rear edge of the house, bearing down on the whole.
>
> Why did Wright design so complex a structure? Why was he so intent on cantilevering? I see Fallingwater as an irregular web of forces skillfully balanced to create floating horizontal levels. It is proper for such a structure to be inserted amid horizontal rock ledges naturally settled by similar adjustments of forces. Moreover, cantilevering is a constituent feature of modern structural technology. For millennia building was dominated by uprights - posts or walls holding up beams, trusses, or vaults to provide shelter. Within the past two hundred years, however, a more scientific understanding of materials and forces gradually led (among several results) to horizontal constructions so strong in themselves that vertical supports can be greatly reduced in number and bulk. Furthermore, supports can be distributed freely between horizontal planes. This technological liberation gave rise to the "open plan" that has preoccupied all major creators of modern architecture, Wright in particular.

The player also will visit a geodesic dome, such as Epcot Center (pending Disney approval). Geodesic domes use a combination of structural engineering techniques (tension, triangulation, beams) to provide strong supports that can withstand external pressures.

The player would be expected to also visit previous sites, particularly the Hancock building and the Eiffel tower. Skipper and Kevin play key roles in this level directing the player to these architectural sites

Content Areas & Pedagogy

A growing number of Engineering educators are concerned that Engineering students fail to think creatively with information learned in traditional classrooms. Learning to think about structural Engineering systemically is particularly challenging as loads, stresses, and forces are all invisible phenomena that operate in relation to one another. Many educators endorse teaching Physics and Engineering through interactive simulations that enable users to gain a qualitative understanding of Physics phenomena (e.g. Forbus, 2001; Sheperdson, 1999).

DreamHaus provides players opportunities to learn about a variety of AP-level Engineering, Mathematics, and Physics concepts. Players engage with the material by solving location-based puzzles, playing with engineering tools in a structural engineering simulator, and designing buildings that withstand extreme conditions. The following concepts are embedded in the puzzle and design tasks. Animations of each are also included in PDA. For a chart of how these concepts are introduced through specific levels, see the GamePlay section.

Solid Mechanics and Mechanical Engineering

- Static equilibrium, force resultants, support conditions, (beams, trusses, frames)
- Stresses and strains in structural elements, states of stress (shear, bending, torsion)
- Statically indeterminate systems, displacements and deformations
- Matrix methods, elastic stability

  Statics and the mechanics of deformable solids
- Basic principles of equilibrium, geometric compatibility, and material behavior
- Linear elasticity with thermal expansion
- Failure modes
- Structures such as rods, shafts, beams, and trusses.
- Mechanical behavior of materials: elasticity, plasticity, limit analysis, fatigue, fracture, and composites
- Triangulation

Newton's Mechanics

Static Equilibrium (First Law)

- Torque and rotational statics
- Dynamic torque
- Objects exert equal but opposite forces on each other (Third Law)
- Static Friction and centripetal force
- Sliding friction
- Weight dependence friction
- angle of repose
- Center of mass/gravity

  - Stress, Strain, Hooke’s Law
  - Stress and its relation to force and moment
  - Strain and its relation to displacement
  - Rotational inertia
  - Mass on a spring
  - Vectors

Architectural Engineering Elements

- Static and dynamic loads on buildings, and effects of wind and earthquakes
- Equilibrium and materials (beams, columns, cables and arches, steel, concrete and wood) activities in tension, compression and bending (stress)
- Some notes on the material we are looking at for puzzles

Architecture Sites

Other Potential Buildings visited on field trip

- Tokyo Olympic Stadium
- Observatory Museum, Japan
- Louvre Pyramid
- Pompidou Center
- Berlin Jewish Museum
- Extension on the Victoria & Albert Museum
- Guggenheim NY
- Guggenheim Bilbao
- Guggenheim Virtual Museum
- Sydney Opera House (new suggestion)

Assessments

Central to assessment theory is the notion that assessment exists to support learning. Therefore, assessment information can be used not only to evaluate learner performance, but also to give them and teachers information in supporting the learning process.

DreamHaus employs a variety of assessment techniques. First, the game engine records:

1) Puzzles attempted,
2) Puzzles Completed
3) Time Spent per puzzle

Second, students’ learning is assessed in the design space, as the CAD software tests students’ understanding. For each level, the software records:

1) Time per design challenge

2) Attempts per design challenge
3) Money Spent per completed
4) Amount of Materials used per design challenge
5) Structural Stability of design (average of all parts)

Finally, the community structure offers unique opportunities for assessments. Similar to The Sims website, The *DreamHaus* website allows users to vote on their designs, create hotlists' of designers they like, see who is on one another's hotlists, and critique other designs online. This space provides valuable feedback on student work, critiquing opportunities, and opportunities for students to have instructors or community members give feedback on their work.

Pedagogy

DreamHaus draws on a variety of constructivist pedagogical traditions, most of which are grounded in David Perkins' work on teaching for understanding and knowledge as design (Perkins & Unger, 1999; Perkins, 1985). David Perkins (1986; 1992) provides a synthesis of cognitive science research, arguing that many learning environments produce learners with missing, inert, or fragile knowledge. Learners may pass tests or graduate from schools, but they do not know how to think creatively with information in contexts outside of school.

Sheperdson (1999) makes a similar observation in engineering education, noting that the goal of engineering education is not to produce students who can recite formulas, but designers who can mobilize physics and engineering concepts in the creative solution of design problems. Perkins and others (e.g. Reigeluth, 1999) have proposed several instructional models for supporting students' creative, critical, and collaborative thinking. *DreamHaus* is an interactive media piece and design tool that can be used within these frameworks. The auditory, visual, digital manipulative, and mathematical embodiment of engineering, math, and physics concepts in puzzles provides allows learners both multiple pathways of understanding as well as multiple ways of representing their understandings, building off of Gardner's multiple approaches to understanding (1999) and Perkins and Unger's Teaching for Understanding (1999).

The design component of *DreamHaus* allows learners to analyze, understand, and create engineering artifacts not as abstract entities, but as enacted systems, allowing them to develop systems-level understanding of engineering phenomena.

It is important to remember that like any educational artifact, *DreamHaus* is a piece of media, a tool that can be used by learners and instructors to support learning – not a selfcontained learning environment. As such, one expects that teachers will adapt and adopt the curriculum in a variety of ways, in accordance with their own pedagogical goals and values. What makes *DreamHaus* unique from a pedagogical perspective is that it uses the appealing allures of romantic history and architecture within an electronic context that is specifically designed to support teaching for understanding and learning by design activities.

The Game Space

Bobbi's *DreamHaus* takes place in an elaborate, vibrant world. A combination of modern and historical structures represent architecture's long, rich history. Bobbi's hip Soho studio is a streamlined, chic space. Bobbi's studio is the player's "home base." Here, she can get a cup of cappuccino or have a chat with Skipper, but the simplicity of the office hopefully draws the player back outside to explore architecture. Outside, Soho buzzes - taxi's honk, bike messengers speed by, pedestrians stroll, looking in shop windows. The player feels as though there is a big world outside and many fascinating, rewarding places to explore. When the player is presented with a design challenge Bobbi's PDA launches her on a "field trip" to an exotic destination. These destinations will be historically accurate but artistically rendered in order to enchant the viewer.

While in the office, there are sequences of humorous, spontaneous banter between Bobbi, Skipper and Kevin. When the player is having trouble with a puzzle Skipper can interrupt and argue with Bobbi about something. Assistance with the science will come through the conversation as Skipper references key information that Bobbi can research in her PDA. Through this bickering and banter, the player investment deepens, as he or she sees the characters develop and exercises agency over the characters decisions.

The spaces/worlds represented in the game include:

- Cut scenes of flashback (non-interactive, cinematics);
- Soho office (character driven and interactive);
- Field trips, exterior and interior of buildings visited (player driven, interactive);
- Puzzle scenes, in relationship to building visited (player driven, interactive with some cinematics);
- The Drafting Board screen and inside the CAD, remote and the teleconferencing virtual world (player driven interactive with some cinematics).

Bobbi's Office.
The world of Bobbi *DreamHaus* is chic and sophisticated. It is the world of cutting-edge architecture. Bobbi's Soho office is a minimalist masterpiece: one would have to be very successful to have so little furniture. It includes:

4) Desk
5) Multiple Drafting tables
6) Chair (how many)
7) Books
8) Lamps
9) Cappuccino maker
10) A sleek stereo

Bobbi's super-powered cell phone / PDA allows her to travel through space to an historical site. There is no explanation of why she has such a special phone: it is part of her chic, cutting edge ambience.

The historical buildings will be atmospheric. The sites will be visited at night so that the ghost can greet them. This will give the sites a bit of a haunting quality. The design space will be sophisticated and aesthetically appealing. Palettes will facilitate student use of tools. The overall feel of the world is elegant, modern and sophisticated.

Bobbi's tools
Tellingly, Bobbi uses or tries to use people as tools.

To arm herself for the battle, Bobbi hires an ace arch grad named Skipper. Skipper is a know-it-all whose brilliance and encyclopedic knowledge of architectural history and science undermines Bobbi's self-confidence. This dynamic works in the game to motivate the player (Bobbi) to spot discrepancies in Skipper's explanations of things-and also to figure out what Skipper is referring to when she makes oblique references to buildings that Bobbi needs to familiarize herself with to meet a design challenge.

Bobbi has an additional secret weapon: her PDA which has supernatural powers, allowing her to travel instantly to any spot on Earth and channel the ghost of the Architect of the building she is visiting.

Characters
Skipper is a resistant tool. Kevin is a tool used in desperation. Ghosts of dead architects resist being used as tools, but point the way to clues.

- Bobbi: The player controlled character. 50 something year old woman. Sophisticated. Angular haircut.
- Skipper: Skipper is a 21 year-old college student (Yale) who is interning for Bobbi. Skipper has a strong background not only in architecture, but in the classics and math and sciences as well. Although she's always the enthusiastic intern on the outside, at times, Skipper is a bit uppity when it comes to sharing her knowledge with Bobbi.
- Kevin: Kevin is the reincarnation of Ken. Kevin is a gay male, also in his 50s. Kevin adores Bobbi, and gains a great deal of his self-worth through his affiliation with her. Kevin isn't as bright as Skipper, although he adds clues on occasion.
- The Money. The money is an anonymous moneybags figure modeled after Charlie on Charlie's Angels. The Money provides Bobbi with tasks to complete.
- Architectural Engineer. The architectural engineer represents the computer. As Bobbi submits designs, the engineer checks them, and a short email is sent back to the player from the engineer highlighting problems and suggesting alternatives (similar to Ken Forbus' work at Northwestern).
- Ghosts of the Architects (1 for each building). The ghosts are modeled after the actual architects. Each ghost plays a tutorial role. The ghost offers encouragement, each for his / her own reasons (e.g. to see Bobbi win the medal. The ghosts are helpful and at times witty.

Game Timeline

Time	Event	Description	Game Experience
1 Min.	B loads game, views cut scene.	Flashback to Bobbi age 35. She has an epiphany that she must become an architect. She leaves Ken in the dreamhouse and heads off to architecture school	
4 Mins.	B learns challenge	Bobbi is in her office in Soho. The first design challenge is presented by the AIA Panel.	
5 Mins	B meets Skipper.	Bobbi and Skipper discuss the project.	B: talk to skipper, read books, or play with design tools?
5-8	B talks to Skipper	Skipper tips B. off on arch sites embodying concepts.	B Decides to visit site
8-15	B visits site	B visits site. Spots clue.	B thinking about design. How does it embody or address the design challenge?
15 Mins	B unlocks challenge	B. meets ghost. Ghost uses animation to explain how building works. Notes appear in PDA	B chooses to view animation. B returns home.
20 Mins	B back in office; beings design	B enters design phase	B uses animations, and other books etc. to design building
75 Mins	B finishes design, submits to Arch Engineer	Architectural engineer reviews design.	
90 Mins	Arch Eng. emails report back	Reports contain tips.	
95 Mins	B fixes design, submits to AIA	AIA reviews design. If accepted, presents next challenge.	
	REPEAT		

- This sequence is repeated six times. Each subsequent level should take between 90-150 minutes to complete. Players can choose to go through all of the puzzles, or only complete the mission critical tutorials.

Game Flow

- The Money introduces the architecture design task. The Money is a wealthy agent who works for the rich and famous. The Money is also Bobbi's agent, and he's working to get her the AIA Gold Medal. He buzzes Bobbi on her PDA. He announces that the client will be visiting the office.

- Client enters the office. The player meets with the client who explains the project--asking for a feature that will require mobilization of target concept(s) in the design. So, the player has to figure out how to create the target feature, but she has no clue where to begin.

She might choose to consult with Skipper, browse her PDA, or start playing in the design space. Let's say she consults with Skipper.

- Figuring out where to go for the clues (with help from Skipper and Kevin). Using conversation trees, the players talk through short dialogs with witty banter that reveals clues. Skipper in her passive aggressive way drops clues that the player must pick up on (see walk-through). This function becomes increasingly important at later levels. As they talk, the player might browse the room looking for a picture of a building (the user can click on an Arch book and leaf through it) that matches Skipper's clues. If the player does not catch-on to the building Skipper is talking about, Kevin enters with the mail which includes a postcard of the target building. Then the player clicks on Kevin and hopefully knows where she has to go.

- Field trip adventure, a journey to and an exploratory tour of a relevant building, transport via PDA. ("Beam me up Kevin.")

- Upon arrival at the building, the ghost of the architect personally greets her. The ghost of the architect draws on the reputation of the architect from biographies. A short dialogue ensues where each ghost explains that he / she would love to help the player, but has his own reason why she needs to figure out the secret of the building herself. As each architect explains this, he introduces the target concept in the building. The puzzle aspect of the game now begins.

- The PDA can also take digital stills of any relevant observations which Bobbi/the player can feed back into the project files database of the digital drafting board. Key concepts are also recorded in the PDA (essentially it's an interactive encyclopedic database of entries). These files can later help to find matches during searches using the shape and materials of the CAD palette or in the Library database (see Interface Notes). She can also tele-conference back to the office to Kevin and Skipper for support.

- The player completes the puzzles, many of which are location base (e.g. find the weakest point in the building or manipulate the building structures to make it stronger or weaker). She searches the building for the target concept/feature and works from one clue to the next. The player may return to the design workshop at any time.

- Solve puzzle=identify physics rule=find key feature which will be the basis for the design task with the assistance of the digital drafting board via the PDA. If the player cannot solve the puzzle with help from the PDA link to the Library and other digital drafting board tools the player must seek help from Skipper.

- Once the set of puzzles is completed, the building is unlocked and may be analyzed in the player's office design / workshop. Here, she enters a design simulation space where she applies the formula to design the target building. As a part of this interface, she can interact with the buildings she has unlocked.

- Back to the drafting board upon return to Soho office Bobbi/player will conduct research on the Library database and look at material relating to conversations and other clues from field trip. The Library is a searchable database accessed by inputting queries in the form of text or 2-D pictures and which works like an interactive electronic encyclopedia yielding entries in response in the form of text and 2-D graphics or animations. The context of these responses includes: building features, styles, historic architecture examples, technical architecture and engineering terms including demonstrations of related physics laws, principles and formula and basic relevant geometry (see Interface Notes).

- Player builds simulation in 3-D (see Interface Notes). The features found in database can morph into elements of a CAD palette by switching digital drafting board from search mode to design mode (choice of materials and shapes to be arranged, rearranged, inter-changed and modified or rejected in order to re-construct even better options). The player can also begin with a blank screen and select shapes and materials from palette. Bobbi/player can design, build simulation and test several versions of the building before deciding on the one to present to the client and panel. This creative challenge can take the longest playtime at hours or over days (followed by field trips and puzzle solving). However, time limits per project might be a condition of the AIA competition to get additional points toward winning the award, (as might coming in on or below budget, if player wants to add the money dimension to the game they can activate that feature within the structural engineering software).

- Test finished architecture design using the engineering assessment software within digital drafting board. The building can only be displayed in final presentation mode if it has passed all assessments and can stand.

- Present final design in 3-D full screen to panel and client by virtual conference including a virtual walk thru of the new building. Level completed. Next assignment takes player to the next level.

- When this is accomplished, she receives a call from AIA with her next challenge/client.

- The following example demonstrates how this would work.

Walk-Through

The client Gwenethka is a Hollywood starlet, deeply influenced by New Age ideas. In order to feel protected both psychologically and physically, she wants her LA pied a terre to be oval. “I don’t want you to cut corners, because I don’t want any corners at all,” she tells the player.

The player doesn’t really know where to begin, so she begins by exploring her environment. Using her PDA, the player calls Skipper into her office to discuss the mechanics of building a house with no corners. Skipper keeps referring back to her weekend in Chile and her fascination with eggs. These are clues dropped to point the player in the direction of a landmark egg shaped Church built in Chile to withstand earthquakes. In The player’s bookcase is a book on Chilean Architectural Breakthroughs. (There may be a few other plants here as well). If the player clicks on the book, it will open to a page featuring an egg-shaped Church in Chile. Aha! The player knows immediately that this is the target building.

If the player does not work it out from Skipper’s clues, she has two ways of discerning the target building. She can play a true or false game with Skipper where she determines whether science concepts presented by Skipper are accurate/not. The player must choose from four choices as to why the concept is inaccurate. Or she can have Kevin bring in the mail. (This is the easy way out). In the mail delivered by Kevin will be a postcard of the target building.

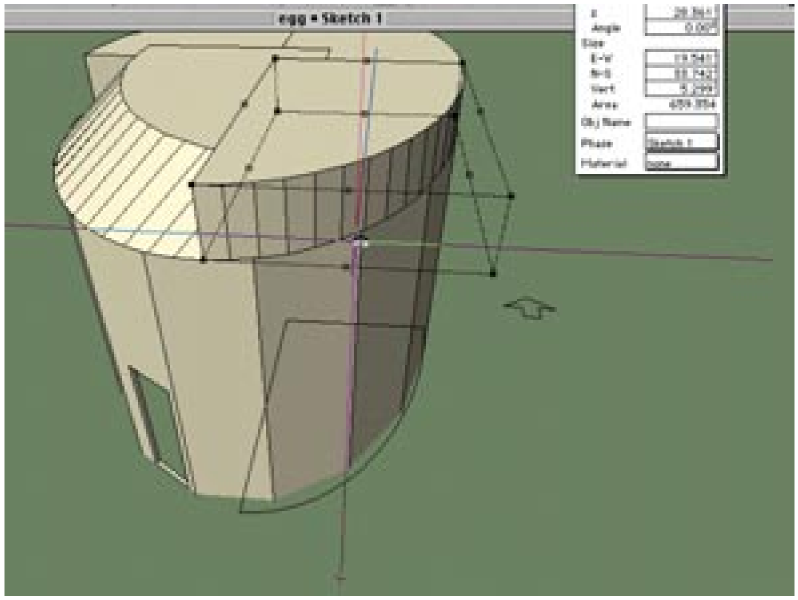
The player travels through her PDA to Chile to the egg-shaped Church. The architect greets her and gives her clues about the target concepts and where to go next to get to the next stage in the puzzle.

In the first clue, the architect challenges the player to find the safest place to stand in the building in the event of an earthquake. When the player finally reaches the correct spot, the room lights up, showing the points of stress in the buildings. The architect talks to the player. Look around you. Where are the points of most stress on the building? What parts are the strongest? Quick! Go find what you believe to be the weakest spot.

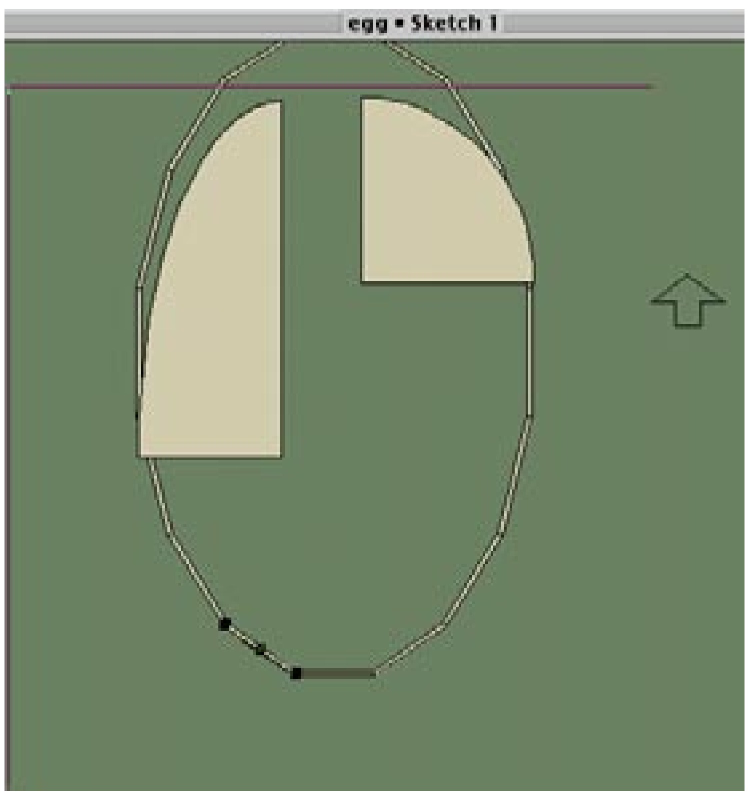
**** Insert Wally’s Here ****

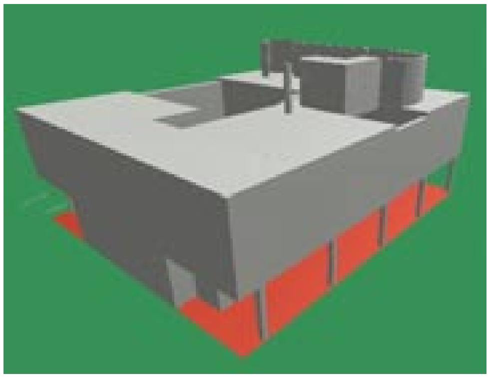
“The player is now back in the CAD space. “Hmmm. The building is supposed to have no corners, so I had might as well start with a circle.” She finds the 2D interface simpler, so she starts with the floor.

“Ok, for the ceiling, I remember that part about arches being strong…so I’ll start by building some arches,” she thinks to herself. She selects an arch from the pallet and puts it in the middle of the screen. Do I stack them? Hmmm…I guess I’ll need more than that,” she thinks as she continues. Next, she jumps back to 3D view and realizes that she has no floor, so she builds a floor, and then walls. Examining her design, she notes that the sides of her building are shaped more cylindrical than circular.



She decides to look up an earlier building that she had worked with, the Villa Savoye to examine the some of the angular and curved surfaces in that building.





After several iterations of design and review through the CAD software, the player has a design that she's happy with. She submits the design for review. It is uploaded to the *DreamHaus* website where her teacher has selected 3 other students (plus herself) to critique the design. The player downloads the three designs into her program and examines the saved designs. Having struggled with the design of a circular roof, she examines the other designs. She notes that one player created a series overlapping domed roofs similar to the cathedrals, and another did a giant dome, whereas hers was quite derivative of the Chilean egg church.

Underwater Level

The money has selected a construction site for the underwater building, including the depth of the building. Skipper suggests that the player look in her PDA to learn more about water pressure. Skipper might also flip through her Rolodex, and call on her friend Theresa (i.e. Barbie's friend Teresa). Theresa is a scuba diver, and the player might recognize that Theresa knows some background information on water pressure.

Once the player finds the formula for determining water pressure at various depths and knows deep the building will be, she can calculate what the actual pressures on the building will be. She then checks the PDA and discovers that pressures in this range would be comparable to the pressures exerted on the bottom stories of a land-building n stories tall.

Checking on the actual construction of such buildings suggests the material requirements of her structure – if the beams are steel they will have to be n feet thick or they will collapse. The beams must be joined by one of several processes that will not snap at these pressure levels. Structures under similar levels of stress will suggest ways she can join the beams. She may find there is a trade-off between the number of beams she uses and the thickness of each. She tries here initial structure and discovers underwater pressure operates in more directions than the land-building example suggested – water presses in as well as down. She must therefore redesign a building that can accept the same levels of stress in all directions.

She goes back to The PDA to look for examples of side-ways stresses on buildings and she discovers that some structures distribute pressure more evenly, thus allowing a lighter framework that achieves the same support-goals. So, her design is based on one pressure calculation and analogy to existing structures.

Failing and Winning.

The interactive feedback system in the digital drafting board gives text and/or verbal advice or asks critical questions (as will Skipper) when a design is submitted (playing the role of the architectural engineer). The simulation examines the efficiency of design (e.g. comparing player's cost to ideal costs) and structural testing. This allows the player to play with designs, and have to think through a design before submitting. The Architectural Engineer might ask if they are sure about a feature or engineering element while at the same time encouraging the player to push the physics of the designs a bit further or to check if they've left something out from a points enhancing check list. They cannot do final display if something could not logically, physically stand. This prevents the presentation of buildings to the client and panel, which could not work. The Architectural Engineer working with the help of Skipper should prevent the player from failing to build a structure that can stand or that will not be acceptable to the client and the panel, but getting Sipper to help is part of the challenge.

While the architectural engineer can test for the basic structural integrity, the panel (e.g. other students or community members) will need to judge the aesthetics and elegance of design. The AIA team awards points based on a rubric detailing the aesthetics of a building, originality, risk, functionality, time (and cost) of completion of the design, adherence to the relevant laws of physics, innovation and risk in structuring engineering. The judging criteria will be for radical, atypical, virtual, deconstructive and postmodern trends in keeping with the project assignments of the AIA panel.

Technology and Interface

I. Game World: Representations of Space and the 3D Engine

The computer-aided-design (CAD) software allows representations of the architectural space as the simulation of a real building. It also allows interactive virtual tours with navigation of the building in real time and 3D views taken from any point, looking anywhere in the building and rotated 360 degree in any plane as a whole or as a fully rendered section cutaway.

This kind of hyper-realism of viewing and interacting with the simulated building within the CAD software on the Electronic Drafting Board requires that the world around it must also seem realistic in terms of real world physics or risk appearing less credible than the architectural models. A 3D physics game engine would be necessary to create a plausible world as well as to demonstrate the physics problems within the puzzle scenes including gravity, rigid bodies, dynamics, kinematics and kinetics.

The game engine must be capable of simulating real-life, real-time, interactive, consistent and persistent physics in the game's world. This reinforces the verisimilitude by allowing the player to experience all of the effects in the environment and the consequences of any actions because all objects interact realistically. The virtual game world will seem complex and with naturalism that increases the feeling of immersion in the game world -- as well as the fun factor.

The 3D engine will have features similar to the game engine Havok.* (See URL below.) In Havok for example, there is no need to try to script all conceivable interactions between virtual objects as the simulation will take care of both normal and unusual game situations so that the player can put impromptu ideas into action creatively and spontaneously.

II. Software and Interface

The player constructs the building simulation in 3-D. As well as the elements found in database, these could include Bobbi's collection of elements generated outside the CAD palette from either the Architecture Library or recorded during field trips. These can morph into elements of a CAD palette by switching Digital Drafting Board from search mode to design mode. The choice of materials and shapes are arranged, rearranged, inter-changed and modified or rejected in order to re-construct ever better options. The player can also begin with a blank screen and select object shapes and materials from palette. Bobbi/the player can design, build simulation and test several versions of the building before deciding on the one to present to the client and panel. They test the finished architecture design using the engineering assessment software within Digital Drafting Board. The building can only be displayed in final presentation mode if it has passed all assessments and can stand.

All of the software applications we are proposing for the Drafting Board and PDA-"Smartphone" already exist or are in the final stages of development. Because CAD and other software described in this document for the Digital Drafting Board, etc. is modeled on existing software applications the game could offer actual software functionality while some features like the teleconferences would be simulated using cinematics.

We have modeled our ideas on the following software: Graphisoft's ArchiCAD,* Geometric Description Language (GDL)* and ArtLantis Render;* Digital Canal's Structural Engineering Frame Analysis,* StrucPro and STRAAD Analysis, on Netopia Inc.'s Timbuktu Pro* and Carnegie Mellon University's Blackboard software,* and on PowerCAD CE.* The Architecture Library is based on the Prestel Sightlines pocket-guide "Architecture From Art Nouveau to Deconstructivism" by Klaus Richter.

When you design in ArchiCAD, you automatically create the simulation of the real building. You raise walls, add windows and doors, lay down floors, build stairs and construct roofs. While you build elements on your floor plan, ArchiCAD creates a central database that can simultaneously manipulate the 3D model data and generate the corresponding plan and section views, dimensions, material finishes, component lists, etc. This means that all the information needed to completely describe the design can be extracted from the project file know as the Virtual Building database. The major features and components of the ArchiCAD software includes:

- The Virtual Building: ArchiCAD stores all the information about the building in a central database; changes made in one view are updated in all others, including floor plans, sections views and elevations and 3D models.
- Intelligent Objects: ArchiCAD's intelligent building elements like doors, windows and columns understand and react to their environment. This allows you to design instead of draft, but even working from drafted lines and shapes, the Magic Wand can turn these into intelligent building elements.
- The ability to think and work "live" in 3D: Architects can design and edit the model in 3D view, navigate in real time to check the design, and hold interactive design sessions with clients.

- Instant visualization: ArchiCAD's rendering tools are simple to use; results include accurate sun studies and cast shadows for any date, time and position on earth as well as VR presentations generated directly in ArchiCAD.
- Internet communication tools: Architects can distribute documents to colleagues, clients and consultants via the Internet for review and mark-up, then merge change requests back into the project.
- Documentation: Construction documents and files can be derived automatically from the Virtual Building model. The bills of material can be quickly generated and always reflect the current state of the building model. The Zone tool identifies and labels rooms, and tracks area and volume, while the components' list shows price, number of pieces and labor costs. Dimensions are both automatic and associative. The Label tool can attach text or symbols to identify parts of your design.

Computer-Aided-Design Palette and Tools

A suite of software will provide system interoperability, integrating each application seamlessly to create the Electronic Drafting Board used by the characters. The Electronic Drafting Board will consist of an Architectural-CAD, which offers a palette of tools to simultaneously design and model the building in real-time using parametric objects creating the virtual simulation of the building.

Intelligent building objects behave parametrically. Parameters are simply rules embedded in the object that govern its appearance and behavior. A window might have parameters that allow the architect to define its height, width, number of panes, material and frame style by dragging and resizing. A wall might contain parameters to define its composition, surface, finish, height, and construction to other walls, columns, floors and ceilings. Parameters can be changed at any time and the complete project will be updated. The Geometric Description Language (GDL) Technology used in CAD systems have made it possible for intelligent 3D building objects to become even smarter.

Intelligent objects in ArchiCAD's intelligent buildings currently includes up to 100,000 parametric-based elements like doors, windows and columns which understand and react to their environment. This accelerates work and makes the design and management of the project more flexible. Even if a designer wishes to work from drafted lines, arcs, splines and ellipses or input elements from sources other than the GDL objects, the Magic Wand tool will create functional, intelligent building objects from those elements.

There are also add-on modules like StairMaker which creates and places custom stairs as parametric objects into your ArchiCAD file or ArchiForma, a simple tool used to generate complex shapes in order to represent: architectural details, furniture or other free shaped elements within the 3D model, which would be difficult to create using the standard construction elements provided within the ArchiCAD Tool Palette. Along with these come further new series of graphic elements, commands and functions to work with.

Bobbi's Drafting Board will have a palette of tools based on GDL with tens of thousands of objects that will be easy to choose from and manipulate and all elements will react intelligently to their surroundings and to one another. For instance, wall intersections will automatically slot together and clean up once placed and roofs will trim walls and other building elements according to user-defined proportions and their placement within the design environment.

Some elements for manipulation within the 3D model, which come from outside of those provided within the ArchiCAD Tool Palette might come from Bobbi's PDA which can take digital stills of the architecture sites, she visits on her field trips and feed these into the project files database of the Digital Drafting Board.

These elements which can be converted to parametric-based objects could be capable of constructing millions of virtual buildings. While the player assembles elements into buildings like the Virtual Buildings of the ArchiCAD software, a central database or project file is created. This project file can provide 3D model data with plan and section views, dimensions, material finishes, component lists and other calculated values.

In ArchiCAD, most functions are accessible through its Application Programming Interface (API). You can also manipulate the database by adding custom parameters to the building elements and saving them into the ArchiCAD file. With this method it is possible to attach, for example, building physics or structural analysis parameters to the elements.

Databases: Architecture Library, GDL Object Library, and Project File Database

The Architecture Library of Bobbi's Drafting Board is an online, interactive, searchable database of 20thC Architecture and accessed by inputting queries in any form, such as text or 2D sketches and plans or 3D models. It should work like an interactive multimedia encyclopedia also yielding results in various forms, text and graphics, models, VR or QuickTime movies or animations. The search categories include: a

Timeline from1880-2000; Names of Architects; Styles; Major Concepts; Technical Architecture and Engineering Terms, information about building features, historic architecture examples, demonstrations of related physics laws, principles and formula and basic relevant geometry.

ArchiCAD comes complete with a library of parametric objects, GDL 3D objects representing real-world building parts. Tens of thousands more are available on CD-ROM and to download from the Web. Graphisoft's Geometric Description Language (GDL) is the building block for ArchiCAD's intelligent objects. GDL contains all of the information necessary to completely describe building elements as 2D CAD symbols, text specifications and 3D models for calculations and presentations.

Conversion and Translator Software

ArchiCAD's file conversion capabilities comply with today and tomorrow's requirements, to ensure smooth collaboration with consultants and colleagues. Not only does it offer file exchange with all major formats including DXF, DWG and DGN, it also supports the IAI's new IFC standard, which allows many disparate applications such as building services design, construction estimating and planning and thermal performance to share data from ArchiCAD's virtual model.

Text and images from the Architecture Library and other databases and sources can be opened in the Drafting Board using DXL, DWG or VRML format translators. Which also provides an environment for live visualization and presentation on multiple platforms whether portable, wireless, remote or networked. Various elements can be exported to ArchiCAD-CAD using DXF format or Bobbi's collection expanded by importing new entries into the Architecture Library. Elements can be exchanged between the CAD and Structural Engineering environments for assessment.

Structural Engineering Software

The Electronic Drafting Board will also include the feature of engineering analysis software that tests the feasibility of the materials and engineering configurations. The structural engineering software is a totally graphical interface with no manual input required, which offers fast and accurate structural analysis of the 3D virtual buildings. It has a built-in range of methods for automatically analyzing and examining geometry, restraints, materials and loading conditions, which lets you concentrate on the specific problems at hand. It offers unsurpassed ease of use in a complete graphics working environment, it also providing all the computational power needed for complex structural analysis. Some key features of Digital Canal's Structural Engineering and Analysis software* are:

- Graphical specification of restraints, loads and geometry
- Section property calculator computes all required analysis and design properties of standard shapes
- Graphical highlighting of forces, deflections or stresses.
- Graphical specification of restraints, loads and geometry
- To-scale renderings of structural shapes allow you to see precise orientation of member.
- Display of Moments, Shear, Deflection and Axial force
- Selective moment of torsion releases
- Loads on all or part of any member
- Factored combinations of load cases
- Built-in library of structural shapes
- Built-in calculation sheet for detail design (CAD to Excel data exchange)
- Graphical highlighting of forces, deflections or stresses
- Animation of deflected shapes
- Quick Modeler modeling toolkit generates the quick creation of standard geometry for 3D rectangular multi-story buildings, continuous beams and frames, trusses, bar joists, domes, barrel vaults, space frames and towers.
- Unlimited Graphical Editing Inside CAD, Flexible interface allows you to change any part of the model at any time graphically.

Digital Canal's Structural Engineering Analysis software is a CAD-based program for 2D and 3D analysis of virtually any structure of unlimited size. The point-and-click interface allows you to load and analyze a variety of models graphically. Integrated design and code checking functions offer a unique two-way communication with the analysis program for automatic updating of the model based on design modification and/or code checking results. Custom reporting options allow you to view the analysis results right on the model and generate custom reports.

Analysis results to can be transferred to other structural or CAD programs for post-processing or redesign. Streamlined input allows you to quickly input the problem and obtain an answer. The module selects from the complete AISC database of shapes. Powerful checking routine is based on stress, deflection, and size criteria and specifies bracing locations for lateral torsional buckling.

Those structural products offer a variety of detailed structural analysis and design solutions for each building's structural needs.

Presentation: ArtLantis Render

The ArtLantis Render application allows users to quickly create high-definition renderings, virtual reality scene and animated sequences; it enriches images with reflection, refraction and transparency effects; it interactively select finishes and apply them to any object in a 3D space; creates realistic scenes using picture mapping, alpha channel, antialiasing, atmosphere functions and bump mapping; ties ArchiCAD materials to ArtLantis' procedural textures to eliminate duplication of effort and applies materials and textures by dragging and dropping from the shader library onto the project.

ArtLantis Render's animation/VR tools include: Create and edit camera paths, camera type and behavior; set speed and timing; link sequences to explore panoramic view with 360 degree perspective; integrated images and atmospheric effects into 3D scenes; control density, scale and orientation; view an object from every angle possible and create VR scenes using QuickTime VR or Real VR format on Win and Mac platforms.

This allows the client to see how it feels to walk through the space, or how sunlight might affect a particular room at different times of the day. Consultants can receive the building data in electronic format, regardless of which CAD platform they are on, make changes and return the file to the designer for further work with no loss of Virtual Building data in the process.

This leading-edge Virtual Building concept and intelligent object technology delivers "computer-aided-design" programs with instant visualization, automatic documentation and true teamwork functionality for collaboration. Graphisoft's Geometric Description Language (GDL) contains all the information necessary to completely describe building elements as 2D CAD symbols, text specifications and 3D models for calculations and presentations with parameters that define object behavior and library parts which are easy to customize.

Mobile Tools: PDA, Remote File Share and Remote Presentation

During the game Bobbi/the players engages in conversation with the architect or the ghost of the architect of the field trip sites. The player uses the Personal Digital Assistant PDA-mobile phone networked to the Digital Drafting Board in the office to record text notes of the interview and to also take digital stills of any relevant observations which

Bobbi/the player can later feed back into the project files database of the Digital Drafting Board. These collected image files can help to find shape matches using the CAD palette or the Library. She can also teleconference back to the office to Kevin and Skipper for support.

PowerCAD CE, the world's first full-featured CAD system for portable/wireless computing devices and features like the remote file transfer programs of Timbuktu Pro and Blackboard could help team collaboration from the field.

Timbuktu Pro (Netopia Inc.) is a remote control and file transfer software which connects and communicates across Windows and Mac OS platforms and support all internet and other networks and connection technology. Timbuktu's powerful collaborative functions allow mobile professionals to securely share screens, display works, transfer project files and communicate instantly and synchronously access functions like a whiteboard space.

Carnegie Mellon University's Blackboard software allows synchronously communication from a distance and access to functions such as an area for slide presentation and real time group discussion capabilities.

Microsoft Corporation's has been working on a Smartphone* development project which combines the best of the PDA to store, access and organize personal information like telephone numbers, a calendar, lists and notes with the best of the mobile phone to create a platform which will keep people intelligently connected, whether by voice, e-mail or other means, anytime, anywhere. Smartphone 2002 will offer users current personal information and e-mail as well as Web-browsing capabilities. The platform will include a Web browser that supports HTML, WAP (WML) and XML formats.

The PowerCAD CE system specifically for portable and wireless computing devices to extends the possibility for design to the field. PowerCAD CE Pro runs as independent portable CAD systems or serves as perfectly synced extensions and mobile companion for leading desktop CAD system allowing you to remotely view and edit billions of existing designs saved in DWG or DXF file formats.

Assessment: Value Calculations for Game Points

In the game the interactive feedback system in the Architectural Engineer gives text and/or verbal advice or asks critical questions at each stage during design, simulation construction and structural testing. This allows mistakes to be caught as the player works on the building. The Architectural Engineer might ask if they are sure about a feature or engineering element while at the same time encouraging the player to push the physics of the designs a bit further or to check if they've left something out from a points enhancing check list. They cannot do final display if something could not logically, physically stand. This prevents the presentation of buildings to the client and panel, which could not work. This technology is built on Ken Forbus coaching technology (2001).

Ultimately the maximum number of points a player/designer receives for each project designed is down to the clever use of the Library, the CAD and other tools of the Digital Drafting Board and to the creativity of each player.

Assessment or the value calculationswill come from two sources, the GDL for design element where values will be set for certain configurations, styles and innovation and in the structural analysis elements for plausibility of physical design, creative innovation of structural configurations and price.

Developments of GDL Technologies in CAD have made intelligent 3D building objects radically smarter. Building product manufacturers can define their entire product families efficiently, as parameters can be constrained to pre-set values to reflect available product styles. Using these same features the game designer can pre-set values to add points for certain stylistic choices Bobbi/the player makes in order to win.

The Section property calculator can compute all required design and analysis properties of specified shapes. An expanded report option can detail and summarize in addition to a step-by-step listing of the computations used to design the member. The structural engineering software module can tell you what AISC equation was used, display the equation and report the calculated value for each step which can also be customized to reflect physics busting originality.

To summarize the engaging aspects of the game include the psychological believability of the characters and the immersive realism of the game environment and the design tools. That in itself will be highly fascinating for players. Add to that the encouragement to creativity and the imaginative and playful way into the subject material of architecture, engineering and physics which could otherwise be so complex and very dry and you have a definite winner.

III. Sound Design

Establishing Bobbi's new maturity and sophistication, a jazz score (think Miles Davis, Kind of Blue) would accompany her entrances and exits and perhaps follow her as she travels on field trips. In lively contrast a hip hop score (true - like Diggable Planets or

US3) will characterize the youthful, hip personalities of Skipper and Ken as well as the downtown locale. By design, the music and effects will emphasize the parody.

Bobbi's PDA will have its own sound effect and The Money will have a signature piece of music. Also there will be a funny sound effect to signal Skipper is coming and one to signal a departure on a trip. When a level is completed another musical segment will celebrate the accomplishment and introduce a cut scene.

As the levels are developed, sound effects and score will naturally develop with them. We aim to make music a core element in the design of the game.

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