CrowdSourced Architecture and Environmental Design

Joseph Thomas Wunderlich PhD[1] and Joseph John Wunderlich[2]

***Abstract*—** CrowdSourcing has become an emerging methodology (and technology) in many disciplines including the natural sciences, biotechnology, and manufacturing. In 2012 the United Nations UN-Habitat's Sustainable Urban Development Network partnered with game developers to upgrade 300 public spaces worldwide by 2016 by joining professional designers with local inhabitants in virtual-world simulations. This work is similar to the lead author's pedagogical research since early 2011 where he has combined 35 years of architectural and high-tech experience, and College & University teaching & research, into a new teaching methodology where architectural game servers and concurrent database servers are configured for peaceful architectural development by players worldwide, and in five college engineering and architectural courses. In one course, students build Japanese villages and gardens, and collectively learn group harmony ("Wa" in Japanese) while reflecting on the physical and spiritual beauty of Japanese culture. In another course, students learn about sustainability as they build green homes, plant gardens, and raise livestock in green villages, or on a virtual college campus, within environments containing simulated weather, terrains, biomes, and AI-enhanced animals. In another course students use the virtual environment to rapidly prototype architectural designs in a collective way, followed by using professional architectural software to complete the design process. Student avatars interact to design, and although the faces and body postures are primitive renderings, they significantly enhance the interpersonal dynamics of students and teachers. Social-media text scrolls down the screen so everybody can be heard. U.S. LEED (Leadership in Energy and Environmental Design) concepts are incorporated, and soon ISO green standards. Future goals included implementing these methods at universities abroad; helping extend the UN concept to developed countries; and merging this research with the author's research in robotics & machine intelligence including interactive environmental maps communicating with real-time robots. Long-term goals include on-line virtual-reality classrooms and laboratories with real-time language translation and lifelike avatars.

Keywords— Architecture, CrowdSourcing, Environmental Design, Virtual Worlds,

I. Introduction

OVER 20 million copies of Minecraft have been sold across all platforms [1]; this creative environment includes various biomes with changing weather, changing daylight, agriculture, livestock, AI-enhanced wildlife, social-media, player-avatars, and a large inventory of materials and tools for building. In this paper we present twenty-one case studies (all but Case 1); twenty of these represent our work including some presented in Japan in 2013 [2]:

Joseph Thomas Wunderlich[1] is with the Engineering Department at Elizabethtown College, Elizabethtown, PA 17022 USA
(phone: 001-717-368-9715; e-mail:wunderjt@etown.edu)
Joseph John Wunderlich[2] is an aspiring architectural student

Case 1: United Nations Projects by Others
Case 2: Initial Designs
Case 3: Building on Public Servers in Creative Mode
Case 4: Building on Public Servers in Survival Mode
Case 5: Building on Public Faction Servers
Case 6: Creating a Protected Creative Server
Case 7: Creating a Protected Survival Server
Case 8: Creating Sustainable Towns
Case 9: Wellness Center Competition #1
Case 10: Creating a Digital-Circuit Design World
Case 11: Creating a Multi-World Server
Case 12: Rapid Prototyping Real-World Architectures
Case 13: Building College Campus
Case 14: Group-build of two Dormitories in Two Hours
Case 15: Group-build of Engineering Center in Two Hours
Case 16: Visit to Australian Architectural Server
Case 17: Creating a Japanese Group-Harmony Server
Case 18: Creating Four Japanese Towns
Case 19: Wellness Center Competition #2
Case 20: Creating a European Architecture World
Case 21: Creating a LEED and ISO Green World

II. United Nations Projects by Others

Fig.1 United Nation Modeling of 300 sites.

The United Nations began using Minecraft in 2012 for sustainable design of 300 sites worldwide; The U.N., architects and planners use this multi-user, social-networking tool to allow the inhabitants of each site to become part of the design process [3]. Although this work began well after our initial work, this international UN initiative provides validation of the use of this game as an educational tool.

III. Initial Designs

The relationship between buildings, plaza's, landmarks, and pathways in a common design style is easily possible within the rapid prototyping of Minecraft. Over thirty buildings and gathering spaces were built off-line by Joseph John Wunderlich in 2011; later collective building experiences with others from around the world would yield

enriched design experiences. A working railroad and ships were included in the initial design worlds in Fig.2 and 3.

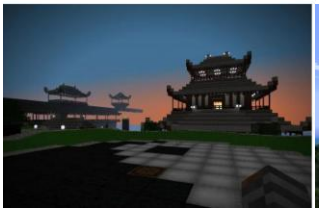

Fig.2 Joseph's Kingdom

Fig. 3 Draft Tsojin world

IV. Building on Public Servers in Creative Mode

Fig. 4 Building on Public Servers

In 2012 Joseph John Wunderlich spent many hours building significant architectures on public servers around the world. These builds, with some help from a few apprentices, led to significant on-line collaboration that would later lead to development of new servers. Unfortunately, on these public servers, architecture is often destroyed by vandals; termed "greifiers." Consequentially, Joseph and a few of his comrades would build complex underground structures with only a small house on the surface as shown in Fig, 4. Or build fortresses in remote locations.

V. Building on Public Servers in Survival Mode

The default mode in some worlds is "survival" where animal behavior is driven by Artificial Intelligence including:

- Flocking, herding
- Predators and prey (including human prey)
- Reproducing animals
- Animals that can be tamed (wild cats, wolves)

In survival worlds all food & materials must be hunted or gathered (including by mining); and tools and some materials need to be crafted. Many quality experiences with other players can be achieved in this mode, however architecture progresses at a much slower pace.

VI. Building on Public Faction Servers

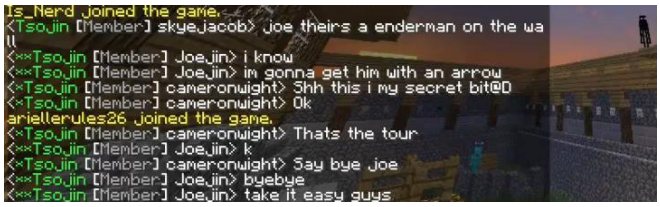

Fig. 5 Dialog on faction server

Some of the strongest bonds can be forged when individuals face adversity together. Joseph built an army on one public faction-server, and built a fortress in the middle of the ocean to protect faction-treasures from raiding parties. This type of world perhaps yields the slowest architecture, but new-found friends would later help create purely creative worlds.

VII. Creating a Protected Creative Server

Fig.6 Town-Center of Protected Creative Server "Tsojin"

In this all-creative world "Tsojin," the initial world architecture and airship shown in Fig. 6, and a player ranking system was created by Joseph. Also, two friends from previous public servers helped Joseph found Tsojin (Eve from Canada and Cameron from England). To-date, these three have not physically met or spoken via phone or Skype. They have only communicated through the social media texting that scrolls down the Minecraft screen, plus a few other social media texting methods. Server configuration, hosting, maintenance, and some moderating was by the lead author (J. T. Wunderlich PhD), Joseph's Father, who also configured a concurrent database server to rollback "griefing" (intentional destruction by other players), and he disabled fire-spread, placing lava, and TNT; and configured the servers as detailed below:

For a more powerful server, the "BUKKIT" server mod "CRAFTBUKKIT" was used to allow:

1. PLAYER RANKING; Joseph defined: ***Guest, Builder, Architect, Master, Admin, and Grandmaster*** -- each having many accumulated commands. BUKKIT plug-ins "ESSENTIALS," "PERMISSIONS," "CHAT," and "GROUPMANAGER" were configured.
2. SQL DATABASE SERVER and plug-in "LOGBLOCK" for logging player activity to allow

rollback of "griefing." The initial release of Tsojin was public. Unfortunately, due to griefing by an organized griefing team, Tsojin was made private.

3. MULTI-WORLD plug-in to allow concurrent worlds (and teleportation & gateways between). Tsojin has six worlds.
4. Many other plug-ins (foul-language censorship, establishing monetary systems, allowing aircraft and vehicles to move, locking chests, etc.).

Fig. 7 Use of Database Server to undo vandalism

VIII. Creating a Protected Survival Server

An additional world was created for those wishing to adventure more than build. This world was accessible from within the main Tsojin Server world.

IX. Creating Sustainable Towns


Fig. 8 One of four sustainable towns.

The 2012 semester project in a Scientific Modeling course was titled *"**Individual Green Home Architectural Builds, and Community-Development Environmental-Planning."*** Part of one town is shown in Fig. 8 including a bio-dome for growing crops in the harsh climate of this town. The following was the project assignment:

PASSIVE SOLAR: Without use of electrical or mechanical devices, let light into house to warm it in winter, but not overheat it in summer. Remember that the sun rises in the East, sets in the West, tracks across the sky at high angles during hot months, and at low angles during cold months. Since Minecraft does not yet have variable sun paths, just be aware of which direction is South – figure it out from the trajectory of the sun. Create overhangs on roofs to strategically shade windows (estimate dimensions), and note that too many west-facing windows may cause overheating. Also, have sun shine on thermal masses to absorb heat during the day and release it at night. Assume thick masonry works very well, and water works even better, but may be more difficult to implement (and maintain).

ACTIVE SOLAR: Simulate solar panels using a black material and place them on your house and around your site to maximize energy generation while not disrupting the movement of people and animals. Creatively angle them towards the sun.

NATURAL DAY-LIGHTING: Maximize the entrance of sunlight into your house while not overheating the house in summer.

MITIGATE COLD NORTHERN WIND: Through site selection, placing of dirt & grass, and design of your building's Northern elevation (including wall thickness and materials chosen), shield the house from cold Northern winds; but consider letting some light in for natural day-lighting and preserving views.

COMMUNITY GARDEN: Help create a large community garden of eatable plants -- till/hoe ground; place water (in adjacent trenches). Plant carrots, potatoes, seeds, etc, and fertilize everything with bone meal.

COMMUNITY LIVESTOCK: Help create animal pens & shelters; breed and/or spawn many animals for meat and producing milk.

ARCHITECTURAL ESTHETIC: House should not only be the ultimate sustainable habitat, but must also be livable and have a high-quality architectural esthetic on the interior and exterior -- so balance all criteria above while creating beautiful architecture. Your architecture should also be complimentary to all else in your village.

URBAN DESIGN and CITY PLANNING: Help create common-areas including piazza's, a central market, a central park, etc., -- and designate a large lot to be used by visiting high-school students to build a Wellness Center in your town (with indoor pool, large activity room, and lockers).

EXTRA CREDIT: Make something electromechanical, and operate it with circuits and logic gates.

X. Wellness Center Competition #1

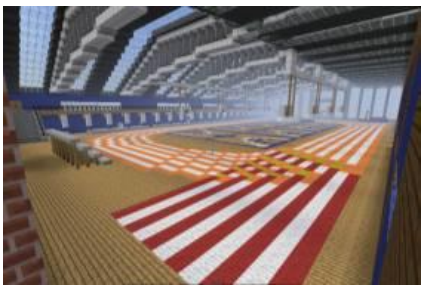
Fig. 9 A Wellness Center Design

In 2012, as part of the College's Engineering recruiting, twenty-four visiting high school students competed in building in one hour, on one of four teams, Wellness

Centers in sustainable towns – with a pool, activity room, and locker rooms.

XI. Creating a Digital-Circuit Design World

Fig. 10 Digital Circuits: Combination lock and Random number generator

In addition to teaching Architecture and Environmental Design, the lead author teaches many Computer Engineering and Computer Science courses where students have used combinational and sequential digital-circuit building techniques in Minecraft to create logic gates, memory devices (Flip-flops), digital clocks, a tic-tac-toe game, and the combinational lock and random number generator shown in Fig.10. These electrical elements have also been combined with mechanical elements (pistons, etc) in many of the worlds to create moving doors and other machinery.

XII. Creating a Multi-World Server

Fig. 11 Portal to another world.

The authors combined the following worlds onto a Multi-world server:

- Main World (Creative Mode)
- Survival World (Survival Mode)
- Digital-Design World (Creative Mode)
- A world for GREEN towns (Creative Mode)
- Two private worlds

All players initially enter in a town-center in the Main World. From there they are directed to a bulletin board building, and then to various portals to other worlds.

XIII. Rapid Prototyping Real-world Architectures

Fig.12. Frank Lloyd Wright's Robie House modeled in two hours.

Fig.13 Wunderlich Home Design modeled in one hour.

Minecraft facilitates rapid prototyping of real world architectures. Fig.12 shows Frank Lloyd Wright's Robie house [4] modeled in Minecraft by Joseph John Wunderlich in two hours, and Fig.13 shows a Professor Wunderlich Architectural Design modeled by Joseph John Wunderlich in one hour. For this project, the actual building was constructed by the athors.

XIV. Building College Campus

Fig. 14. One of many College campus buldings

Most of the entire Elizabethtown College campus was modeled in Minecraft by one very talented student.

XV. Group-build of Two Dormitories in Two Hours

Fig. 15. Group-build of two dormatories in two hours

In 2012, the Elizabethtown College Hackman Apartments were team-built in only two hours by 16 students in College courses:

- EGR280 Engineering Research
- FYS100 Scientific Modeling for Sport

Four team leaders set standards and toured the actual buildings before the team-build. These four team leaders developed skills on Tsojin during the summer before their freshman year. Significant peer mentoring was observed on this build.

XVI. Group-build of Engineering Center in Two Hours

Fig. 16 Group-build of engineering center in two hours

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In 2012, the Elizabethtown College Masters Center exterior (with the footprint and a section of facade created in advance), and 50% of interiors were team-built in three hours by 40 students in the College courses:

- EGR280 Engineering Research
- PH275 Cognitive Science
- FYS100 Scientific Modeling for Sport
- EGR332 Computer Organization & Architecture
- EGR343 Green Architectural Engineering

Ten team leaders set standards and toured the actual building before the team-build.

XVII. Visit to Australian Architectural Server

In 2013, on the scheduled day of a group-build for first-time designers in one of Professor Wunderlich's courses, the hosting server company suddenly declared bankruptcy. So a quick alternative event was scheduled where each student went onto a designated architectural server in Australia and built a home on a designated lot in two hours, The inhabitants and owners of that server were great hosts and will likely be contacted again for future group architectural and environmental design activities. Note that third party hosting allows continuous running of servers for a fee. However, for the first two years of our work the servers were run on our home machines. This was more convenient for server configuring, but would sometimes involve taking the servers off-line when the authors were traveling.

XVIII. Creating A Japanese Group-harmony Server

After the authors presented some of their initial work in a key-note talk in Japan in 2013 [2], and then extended the trip two weeks to study Japanese architecture (mostly in Kyoto), the lead author created lectures on Japanese architecture and environmental design for new students preparing to create Japanese towns on a new Wunderlich server in Fall 2013. Figures 17 to 26 are excerpts from these lectures:

Fig. 17 PATHS - *Channel water*

Fig. 18 PATHS - *Channel water*

Fig. 19 PATHS - *Channel people on water*

Fig. 20 PATHS - *Channel people on land*

Fig. 21 PATHS and EDGES – *Gateways*

Fig. 22 NODES – *Gathering people*

Fig. 23 NODES – *Gathering people*

Fig. 24 DISTRICTS – *Gathering people*

Fig. 25 DISTRICTS – *Community gardens*

Fig. 26 DISTRICTS – *Tranquil retreats*

After the authors returned from Japan in 2013, the new Tsojin Server was launched using the original Tsojin town shown in Fg. 6 as the "Spawn-Point" for the new server. The town was contained in a specially-protected envelope so that nobody could bulid in it; and only use it for inspiration and to read posted directives; Also, four new town territories were defined for four teams of new Scientific Modeling course students to build Japanese towns and gardens.

XIX. Creating Four Japanese Towns

Four new town territories (prefectures) were defined for four teams of new Scientific Modeling course students to collectively build Japanese towns and gardens on the new Tsojin Server in 2013, and to individually build a traditional Japanese home. Some results are shown in Fig's 27 to 33.

Fig. 27 PATHS - *Channel water*

Fig. 28 PATHS - *Channel people on water*

Fig. 29 PATHS - *Channel people on land*

Fig. 30 PATHS– *Gateways*

Fig. 31 NODES– *Gathering people*

Fig. 32 DISTRICTS – *Community garden and livestock*

Fig. 33 DISTRICTS – *Tranquil retreats*

The project expectations where defined as:

- Thoroughly research small town planning, sustainability, and the culture of Japanese communities in the late 1800's
- Build a late-1800's Japanese town with your teammates in your prefecture. Include a central market, central park with Japanese garden, community garden of eatable plants (till, irrigate, plant carrots, potatoes, seeds, etc, and fertilize), livestock in animal pens (breed for eating and producing milk)
- Designate a large lot for visiting high-school students to build a Wellness Center in your town; they will build a meditation room, tranquility pool, and Japanese garden.
- Designate a lot for your home.
- Do not build outside of your prefecture; I will use my database logs to see exactly who built what.
- Thoroughly research traditional Japanese homes and the culture of Japanese families in the late 1800's
- Your traditional-style Japanese home must include:
  PASSIVE SOLAR *(Same as in Section IX above)*
  THERMAL MASS *(Same as Section IX)*
  NATURAL DAY-LIGHTING *(Same as Section IX)*
  MITIGATED NORTHERN WIND *(Same as Section IX)*
  ARCHITECTURAL ESTHETIC *(Same as Section IX)*
  Architecture must be complimentary to all else in village, and to group harmony ("Wa") of the village.
- Build on your lot a private Japanese garden with a pond.
- Community Japanese Garden must reference the course text.

XX. Wellness Center Competition #2

Fig 34 Wellness Center in a Japanese Town

In 2013, visiting high school students again competed in building in two hours, Wellness Centers; but unlike in 2012 in "Sustainable Towns" where everyone built a pool, activity room, and locker rooms, this contest required wellness centers in Japanese Towns to contain a meditation room, tranquility pool, and Japanese garden. One design is shown in Fig. 34.

XXI. Creating a European Architecture World

In Fall 2014, a new Server will include a world of European Architecture begun by Joseph in Fig. 35 and 36. This world will be used in a Conceptual Architecture course.

Fig. 35 European Architecture World

Fig. 36 European Architecture World

XXII. Creating a LEED and ISO Green world

In Fall of 2012, LEED Green Architectural and Environmental Design principles were taught by the lead author as part of Elizabethtown College's EGR343 Green Architectural Engineering, and students were only partially involved in CrowdSourced design projects. In Fall of 2014 this course will include more CrowdSourcing, plus inclusion of ISO Green standards often used outside of the U.S.

XXIII. Conclusions

The twenty-one case studies presented show that Minecraft can be used for creation of architectures and towns, where group harmony and sustainability can be achieved collectively and individually through CrowdSourcing. Future goals include implementing these methods at universities abroad, and merging this research with the lead author's research in robotics & machine intelligence including interactive environmental maps communicating with real-time robots. Long-term goals include virtual classrooms and laboratories with real-time language translation and lifelike avatars.

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Joseph Thomas Wunderlich. PhD Electrical & Computer Engineering (U. of Delaware), M.Eng. in Engineering Science (Penn State U.) has 25 years of Computer Engineering experience including two neurocomputer designs and partial design of an IBM supercomputer operating system. He also has 10 years of architectural experience including a BS in Architectural Engineering (U. of Texas, Austin) and 39 credits towards a 2nd BS in Environmental Design (U. of California, San Diego). He's taught 32 different courses and created programs in Sustainable Design Engineering (BS) and Architecture Studies (Minor). He was Project Director for $90M of architecture in Texas, California, and Pennsylvania in the 1980's including contributing to award-winning architecture. **Joseph John Wunderlich** is an aspiring architectural student.