A Collaborative Design Simulation Game

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Collaboration is an is an important aspect of the architect's education. However, it is not amenable to the traditional project-based learning pedagogy that works so well for developing form-making skills, because it can only be revealed when the number of participants exceed a certain threshold, and when actions made by others affect the individual's design decisions. The advent of on-line, multi-player games provides an opportunity to explore interactive collaborative design pedagogies. Their abstraction helps focus attention on the core issues of the simulated phenomenon, while the playful nature of a game, as opposed to 'work,' encourages immersion and role playing that contribute to the learning process. This paper describes an on-line game for simulating design collaboration. It espouses to simulate, exercise, and provide a feel for the social dimension of collaboration, by embedding mutual dependencies that encourage players to engage each other – in adversarial or collaborative manner – to accomplish their goals. Specifically, it is intended to help students understand what is collaboration, why it is necessary, and how it is done. The game is modeled after popular board games like Scrabble and Monopoly: players build 'houses' made of colored cubes on a site shared with other players.' A carefully constructed set of rules awards or deducts points for every action taken by a player or by his/her neighbors. The rules were constructed in such a manner that players who collaborate (in a variety of ways) stand to gain more points than those who do not. The player with the most points 'wins.'

1. Introduction

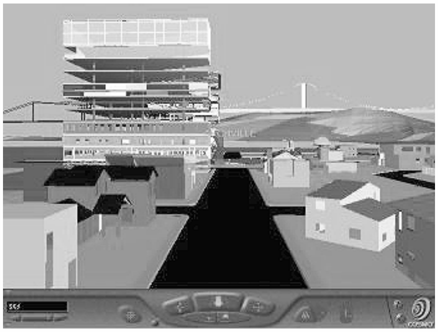
Collaboration is an important aspect of the architect's education that is often neglected in favor of developing form-making skills. As a result, it is the misleading image of Howard Roark, the fictional hero architect in Ayn Rand's 1943 novel The Fountainhead, that many students envision when they choose to study architecture: a professional who is in complete command of his/her destiny and the project. It is not until they graduate that students confront the socially complex reality of architects as agents in a collaborative enterprise, subject to a multitude of rules, regulations, economic realities, speculation and negotiation that constrain and direct their own professional contributions.

Moreover, collaboration is not amenable to the project-based learning pedagogy that works so well for developing form-making skills, because it can only be revealed when the number of participants reaches a certain critical number, and when actions other than the designer's own are in evidence. For the same reason it is not amenable to lecture or seminar style teaching, whose abstract nature allows students to comprehend the social dimension of the process only intellectually, without actually experiencing it.

Attempts to introduce UC Berkeley students to the social dimension of architectural design have begun in the late 1970s, through a comprehensive design exercise given to third year students directed by Architecture Professor Marc Treib (Figure 1). It was intended to teach them, among other things, how to deal with the creation of places as a collaborative form-making enterprise, rather than as an individualized effort. The exercise involved the design and physical construction of a cardboard 'city' in a pre-designed 'urban landscape.'

► Figure 1. Cardboard City (c. 1980)

Students were assigned 3'x3' plots in the yard, and instructed to design a 'defined place for sitting.' Although the project was assigned as an individual design task, many students opted to work in groups, thus maximizing their resources. As in real life, they soon found out that group work often entailed endless discussions and political power plays, which offset the time and resources saved. Students were required to make an effort to conform their designs to the designs of their neighbors, or come to some common agreement on the vocabulary of form. This last requirement, together with group work effort, turned the Cardboard City project into an exercise in collaboration, as much as it was an exercise in physical design. Students learned the importance of politics in design, the destructive force of obstructionists, and the impact of decisions made by others on their own designs. It became the 'right of passage' exercise to upper level studios, and a source of pride to the students who participated in it. But the creation of a large scale cardboard city by 75 students also inflicted so much damage on the studio facilities, in terms of cardboard mess, gauged tables, floor tiles, and any other surface the students could use for cutting, that the exercise was discontinued.


◀ Figure 2. Archville (2000)

The advent of computing technology, in particular the Internet, allowed us to resurrect the Cardboard City exercise in the late 1990s, using computer visualization in lieu of cardboard (Figure 2). *Archville*, as the new exercise was called, was pedagogically similar to the Cardboard city exercise (Peri 2001). As with the original exercise, each student was given a plot in an urban landscape. Instead of a physical space, *Archville* used a computer model of a hypothetical city. Instead of reduced-scale 3'x3' physical plots, students were assigned 'life-sized' virtual plots. Instead of designing a 'defined place for sitting,' students designed houses or other structures. As in the Cardboard City exercise, students were asked to design their houses in agreement with their neighbors. Specifically, they were required to establish and agree upon some common design elements, such as style or color. Using VRML, *Archville* allowed students to 'walk' through the 'city' virtually. Each student's work was always visible to other students, eliminating the problem of making design decisions based on obsolete information. Students could also see each other walking though the environment, in the form of avatars, and communicate with fellow students by chat and e-mail. Work that has been done in previous semesters was not 'taken down' at the end of the exercise, as in physical design studios. Rather, it was left on the site, creating a sense of history and a city that grew and evolved over the semesters. When more space was needed, more landscaping was added to the computer model.

Paradoxically, *Archville's* advantages have also been its limitations: students put most of their effort into creating their individual buildings – a time consuming activity accomplished through commercial CAD tools like 3DstudioMax, FormZ, and VRML – leaving little time for exercising the social dimensions of the project. Our attempts to extend the exercise to include such dimensions as economics, negotiations, and tradeoffs, failed to dislodge the students' preoccupation with form-making.

A similar tendency to focus on form-making, rather than the social aspects of the architectural design process, was exhibited when the virtual environment was substituted by a physical scale model of a city. Called *CADville*, this exercise combined computer-aided design and physical scale modeling to create 80-100 houses that were located on scaled city plots. The students were asked to respect (actual) local zoning laws, existing structures and morphologies, and coordinate their designs with other students in their immediate vicinity (Figure 3).

► Figure 3. CADville (2002)

The result was a scaled-down city center, which generated much excitement for one afternoon every semester. But the students' preoccupation with their own designs, their reckless disregard of the design of fellow students, and the difficulty of (manually) enforcing collaboration, resulted in architectural chaos. While this result was appreciated by the students, and served to underscore the need for collaboration, it did little to help them actually experience it.

To overcome the students' natural tendency to focus on form-making, and to concentrate their efforts on the collaborative aspects of the design process, we have been developing a simulation game that provides a simplified framework within which a sufficient number of students can experience the social dynamics of the design process. In essence, it replaces complex form-making with simple colored cube-shaped 'rooms,' which the players must 'buy' or 'trade' with each other. Instead of intricately-crafted buildings, the game emphasizes the impact of actions taken by fellow 'designers' and the opportunistic nature of forming collaborations on the individual students' ability to accomplish their own goals.

2. Simulation games

The use of game-like strategies to benefit learning processes is well-known in education, where knowledge acquisition is often done through the medium of games (Dewey 1957). Their potential to enhance architectural education has been suggested by several researchers (Hubbard 1980, Woodbury 2001, Scriver & Wyeld 2001). Games have the property of simplifying complex phenomena, and putting the players in an un-encumbered learning mood. By using abstractions and well-defined (if not always explicit) rules, games focus on the core issues of the simulated phenomenon. Players are introduced to the simulated principles in an active, playful manner, as opposed to formal lectures or even course projects. Abstraction prescribes a limited 'solution space' of possibilities, framed by a mutually respected set of rules. The playful nature of a game, as opposed to 'work,' encourages immersion and role-playing that contribute to the learning process.

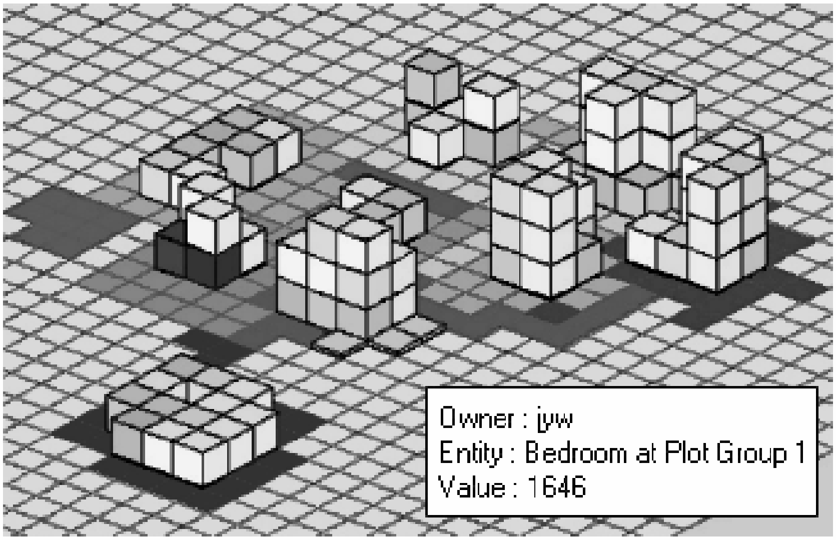
The same properties that make simulation games an attractive pedagogical tool also makes their development difficult: it is a thin line that separates the retained principles of the simulated phenomena from the discarded ones, and that establishes the game as a pedagogical tool, compared to entertaining but intellectually trivial pastime.

Of particular interest to this project and to the pedagogy it espouses is the social dimension of games: players must engage each other – in adversarial or collaborative manner – to accomplish their goals. This can be done by embedding mutual dependencies within the game, which help to elucidate the social, collaborative nature of design. The robustness of the game as a structure of design-thinking, and its ability to elicit playful yet critical inquiry, further enhance the appeal of using the gaming analogy to learn about the social nature of architectural design.

3. The collaboration simulation game

To exercise and provide a feel for inter-dependent decision making, albeit in a highly abstracted form, we have developed a collaborative on-line design simulation game. Specifically, it is intended to help students understand what is collaboration, and why it is necessary, by providing positive reasons to collaborate (to achieve more than can be done alone), and illustrating the negative effects of lack of collaboration (e.g., interference with one's ability to accomplish his/her goals).

► Figure 4. The collaborative on-line simulation game (2003)



The vehicle we chose for implementing these objectives is building a 'house' made of colored cubes, on a site shared with other players who build their own houses (Figure 4). A carefully constructed set of rules awards or deducts points for every action taken by a player or by his/her neighbors. Players who collaborate (in a variety of ways) stand to gain more points than those who do not. The player with the most points 'wins.'

3.1. Method

The game is modeled after popular board games like Scrabble and Monopoly, though without 'turns' (players do not have to wait for others to complete their transaction to make their move). Players build 'houses' on a gridded site. The houses are equivalent to Scrabble's words: they are made of individual cubes (equivalent to Scrabble's letters). Each cube represents a different type of 'room,' and has a certain point value (different types of rooms have different point values). Adjacency rules restrict the allowable placement of cubes (which cubes must be adjacent to other cubes, and which cubes must not touch one another). Additionally, a complete 'house,' much like an acceptable word in Scrabble, must include a certain number of cubes of certain types (the equivalent of having a bathroom, a kitchen, a bedroom, etc.). The value of a house depends on the number and types of rooms it is made of (i.e., a small house may have only a kitchen, one bedroom and one bathroom, whereas a large house may have a kitchen, five bedrooms and three bathrooms).

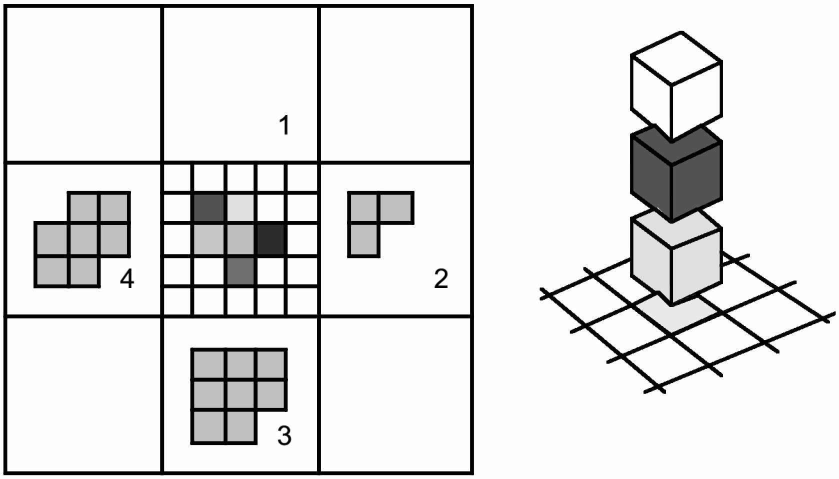
3.2. Economic model

To encourage collaboration, the value of each player's house is affected not only by the value inherent in the cubes that make up the house itself, but also by the improvements made by neighbors to adjacent houses. Thus, a house that neighbors large houses has more value than a similar house that neighbours small, or un-developed plots. The economic model underlying the game is thus based on real-estate 'speculation': players gain points through growth in the value of their property, due to the development of their own plot, as well as through the development of plots owned by other players. Improving one's own property causes adjacent property values to increase as well. It is in the players' best interest, therefore, to help their neighbors improve their properties.

Property is defined as a contiguous set of squares belonging to the same player (a player may have more than one property). Its value is calculated according to the following formula:

$$V_p = \sum S_{i,p} * I_p * \prod N_{j,p} \quad (1)$$

where $\sum S_{i,p}$ is the sum of the values of all the squares from which the property is made; I_p is the overall improvement factor; and $\prod N_{j,p}$ is a 'neighbors factor' multiplier



◄ Figure 5. calculating the value of I_p as the sum of the values of the values of the plot and the cubes on that square

The value of each square $S_{i,p}$ is calculated as follows (Figure 5):

1. Original value of the square (as determined by the site).
2. The value added by each room associated with this square.

The 'improvement factor' I_p is calculated as follows:

0.9 – if the property is not owned by any player
1.0 – if the property is owned by a player who made no improvements to it (i.e., no rooms, landscape)

1.1 – if the player has purchased some rooms, but they don't yet add up to a 'house'
1.2 – if the player has built a small 'house' (kitchen and one bathroom and bedroom)
1.3 – if the player has built a medium 'house' (entrance, kitchen, two bathrooms and three bedrooms)
1.4 – if the player has built a large 'house' (entrance, kitchen, three bathrooms and five bedrooms)

The 'neighbors factor' $N_{j,p}$ is the product of each neighbor's property value index, calculated according to the following algorithm:

a. Set $N_{j,p} = 1$
b. For each neighbor j calculate its own Improvement Factor I_j
c. For each neighbor j of P: $N_{j,p} \leftarrow N_{j,p} * I_j$

A 'neighbor' is defined as an adjacent property that shares n squares with the evaluated one (pro-rated according to the ratio of n to the entire perimeter).

For example, the house depicted in Figure 5 would have the following value:

$$V_p = \sum S_{i,p} * I_p * \prod N_{j,p} = 450 * 1.3 * 2.002 = 1{,}171.17$$

calculated as:

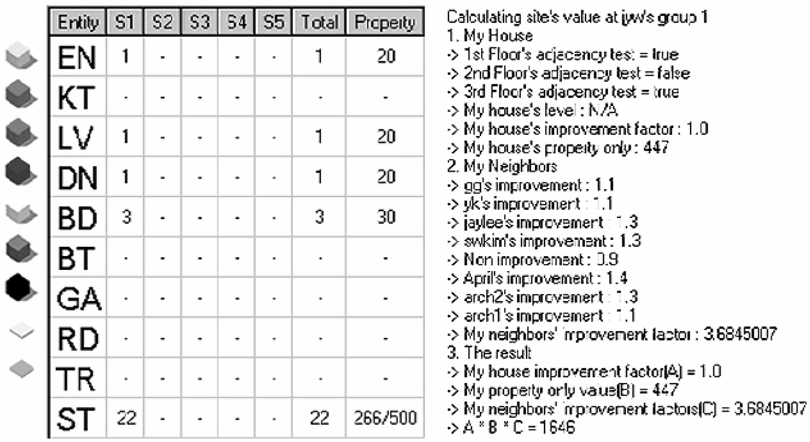
$\sum S_{i,p}$ = values of all squares + improvements = 450
I_p = 1.3 (medium house)
$N_{1,p}$ = 1.0 (owned by a player, but no improvements)
$N_{2,p}$ = 1.1 (not yet a house)
$N_{3,p}$ = 1.3 (medium house)
$N_{4,p}$ = 1.4 (large house)
$\prod N_{j,p}$ = 1.0 * 1.1 * 1.3 * 1.4 = 2.002

Note the dramatic effect of the neighbors' houses: although the player's investment in the property amount to only 450 points, its value-according to this example-is over 1,171 points. If all neighbors had build large houses, its value would rise to more than 2,247 points. This dramatic effect should be enough to encourage players to help each other improve their properties.

3.3. Implementation

The game has been programmed in Java, as a multi-user, web-accessible domain. It allows for accommodating a large number of players, administering the rules and calculating point values. Players log on to the game web site, where they are able to see what other players have been doing, and communicate with each other through chats and e-mail.

In addition to tools that allow players to add, remove, re-locate cubes, and change the view parameters (zoom, rotate, etc.), several tools allow players to gain information about the status of their own and other player's buildings. One tool, called 'property' (Figure 6a), lets players see what types of rooms they have acquired, and what is the state of their resources. The other, called 'consol' (Figure 6b), allows them to study in detail how the value of their-and other players-property has been calculated. Together, these tools provide total transparency to all players. The information can be used to determine where improvements may be made, either to one's own property or to his/her neighbours. Total transparency is a key element in collaborative arrangements, although it can be used for individual gains as well.



Entity	S1	S2	S3	S4	S5	Total	Property
EN	1	-	-	-	-	1	20
KT	-	-	-	-	-	-	-
LV	1	-	-	-	-	1	20
DN	1	-	-	-	-	1	20
BD	3	-	-	-	-	3	30
BT	-	-	-	-	-	-	-
GA	-	-	-	-	-	-	-
RD	-	-	-	-	-	-	-
TR	-	-	-	-	-	-	-
ST	22	-	-	-	-	22	266/500

◄ Figure 6. (a) the property inspection tools allows players to see the status of their resources; (b) the Consol tool allows them to find out how the value of their own and other players properties have been calculated

4. Collaboration strategies

Players are assigned a given sum of 'money,' in the form of points, at the start of the game, which they can use to 'buy' cubes and plots. Much of the game's strategy, however, is in the types of agreements the players make among themselves, which lead to *association, teamwork*, and even *creative* collaborations:

1. ***Association*** occurs when players organize into groups that make joint purchases of plots or rooms, thereby avoiding the speculative, inflationary effects of development: they can 'buy' undeveloped plots, rather than buy into an already developed location.
2. ***Teamwork*** occurs when a player purchases a large number of cubes ('rooms') of a particular type and 'rents' them to others. 'Renting,' in the context of this game, means that the original player retains 'ownership' of the cubes, but they are used in constructing other

players' houses. The owner is 'paid' in points whose number is proportional to the value of his/her rented room within the context of someone else's house. Thus, 'renting' represents specialization of individual players, who choose to 'invest' in one type of cubes. Players may even choose not to build a house of their own, only 'rent' their cubes to others.

3. ***Creative collaboration*** occurs when two or more players decide to share their resources and combine their talents in pursuit of more expensive plots or more elaborate houses. In this case, the rewards are also shared.

Despite the simplicity of the game, the flexibility afforded by the cubes, the plots, and the rules provides for a rich gaming environment, which can be tested and changed subject to mutual consent of the players. Concepts borrowed from the business world allow participants to test different methods of contracting, including multi-player secondary and tertiary agreements that may be needed to complete a 'deal.'

5. Conclusions

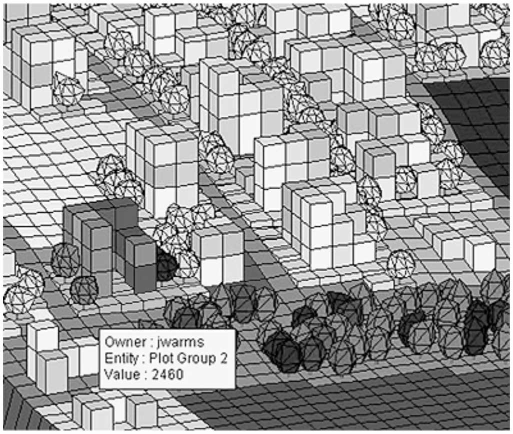
The simplification of the 'buildings' to colored cubes had the desired effect of focusing the players attention on gaming strategies, rather than on building beautiful houses. Such gaming strategies, however, tended to be self-centered, and adversarial, rather than collaborative.

The first implementation of the game allowed players to purchase individual 'squares' for their building site. Students quickly discovered that the most profitable strategy does not require collaboration, only maximization of the number of neighbors. This could be accomplished by purchasing squares that made for highly irregular plots, with 'tentacles' reaching the sites of as many other players as the geometry allowed (see Figure 4). A side effect of this strategy has been 'chocking off' other players, by surrounding their site with a single row of squares.

To counter this strategy, the game was modified to consist of pre-defined plots, much like a housing development. Players could purchase only entire lots, rather than single squares. This restricted their neighbors to a fixed number, and put the emphasis on collaboration (Figure 7). Figure 7 also shows the beginning of visual improvements made to the game, in the form of trees, roads, and other amenities.

The game was made part of an introductory course to computer-aided architectural design (ARCH 132) in Fall 2003, a course that enrolls some 80 students. Students used it to develop a conceptual model of a house, while learning the principles of design, economics, and collaboration.

It is envisioned that the game 'engine' will lend itself to exercising other subject matters and pedagogies. For example, it could be used to teach different business models, economic models, social models, and political models. Clearly, the kinds of rules needed to support such pedagogies will have to be carefully considered, a task that can only be done when the game is available for testing them.



◀ Figure 7. The modified game allows players to purchase only pre-defined plots, thereby changing the gaming strategy into a more

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Yehuda E. Kalay and Yongwook Jeong, Department of Architecture, University of California, Berkeley, Berkeley, CA 94720, U.S.A

kalay@socrates.berkeley.edu
ywjeong@uclink.berkeley.edu