

# V!RUS

Sistema.System | Revista do Nomads.usp - Nomads.usp journal - issn 2175-974x | sem 01-10

## **Design wiki: a system for design sharing**

**Wael A. Abdelhameed, Yoshihiro Kobayashi**

Wael Abdelhameed is an Architect, Doctor in Computing Architecture, Assistant Professor at the University of Bahrain. His research areas are 3D Modeling Systems, Computing Architecture, Virtual Reality, Design Process, Visual Design Thinking and Digital and Manual Media Interaction.

Yoshihiro Kobayashi is a Faculty Researcher Associate at the School of Architecture and Landscape Architecture (SALA) at the Arizona State University (ASU), USA. His research focuses on 3D City modeling using soft computing and photogrammetry technologies.

HOW TO QUOTE THIS TEXT: ABDELHAMEED, W.A.; KOBAYASHI, Y. **Design wiki: a system for design sharing**. In V!RUS. N. 3. São Carlos: Nomads.usp, 2010. Available at: <http://www.nomads.usp.br/virus/virus03/submitted/layout.php?item=7&lang=en>.

Accessed: MM/DD/YYYY

## **Abstract**

This paper presents a comprehensive review in the areas of Networking Community and Forum, and proceeds further to introduce an innovative system of design sharing, called Design Wiki. Design Wiki is a design database that has a massive number of two and three dimensional designs, applying the Wiki concept through allowing its online users of designers to search, visualize, modify and then save its different designs. The paper through the proposed system presents a process to generate 2D/3D designs in a networking database that has a design tool to modify the existed designs. The designs in the system are arranged and linked together according to their topological properties. The consideration and future work are discussed.

## **INTRODUCTION**

Collaborative design concept introduces a design file designers can modify its content at different geographical locations through the Internet, which is the essence of the online community and forum. These communities and forums massively spread by the Internet, applying different areas, many of which are related to design and building construction, for example Online Libraries, Building Management Systems, Facilities Management Systems. Researchers introduced many new approaches and applications, such as Open Design Environment, Networked Open Design Environment, etc. However, acknowledging and imparting the Internet use as a part of the designing process itself was an effective contribution especially to the design knowledge access.

These foregoing approaches and concepts were investigated by previous researches in terms of enhancing the architectural design realm and its various areas, e.g. design process, architectural education, design studio, etc.

This research was partially funded by the Fulbright Commission as a postdoctoral research, and represents a part of a research series that employs the Wiki concept in different design disciplines. Wiki is a networking system that allows its anonymous users to add, remove, and even edit its content.

The Design Wiki system presents three concepts and approaches:

- 1) Design Wiki, the concern of this paper, that applies the Wiki concept in design,
- 2) Visual design map, that acts as a visual database of 2D and 3D designs through

networking, and

- 3) Three dimensional modeling system, that is unique through its simplicity in perceiving and using the offered functions of: Modify, Delete and Save.

## **1. MOTIVATION AND OBJECTIVES**

Our paper motivation is to contribute to what have been previously investigated and presented in research areas of: collaborative design, networking, and online communities and forums. The paper introduces an a framework of Design Wiki that is a system for design sharing, and presents: a three dimensional modeling system that helps modify the displayed designs, and a visual design map that classifies and saves the designs in a visual database.

The paper objectives are: 1) introducing a review of the related research areas previously stated, 2) describing a framework of Design Wiki, and 3) presenting the system functions through some case studies.

## **2. REVIEW OF RESEARCH AND APPLICATIONS**

Networking builds on the particular opportunity to contact and relate with any community of interest, to share visual data through web. Applying networking in design avails to the participants of the design team highly specific contextualized information, in order to reflect each participant's evaluation of the proposed design actions. This part of the paper presents a comprehensive review of what have been accomplished in both levels of research and application.

The paper classifies the networking applications, as follows: file sharing, source sharing, and source sharing through an agent, Figure 1, and proceeds to present some applications that have been used commercially.

### **2.1. File Sharing**

During the 80's, file-sharing concept was appeared through allowing different Internet users in different locations to share a certain file; the users were limited persons linked to the same network, Figure 1.

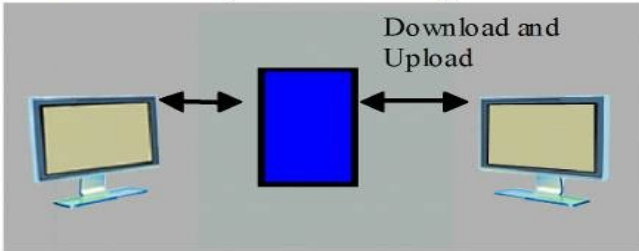
Of the early prominent researches in the areas of Collaborative Design and Networking was the work of the Sasada Laboratory at the University of Osaka in Japan:

- - Sasada (1995) maintained that computer graphics, including computer generated

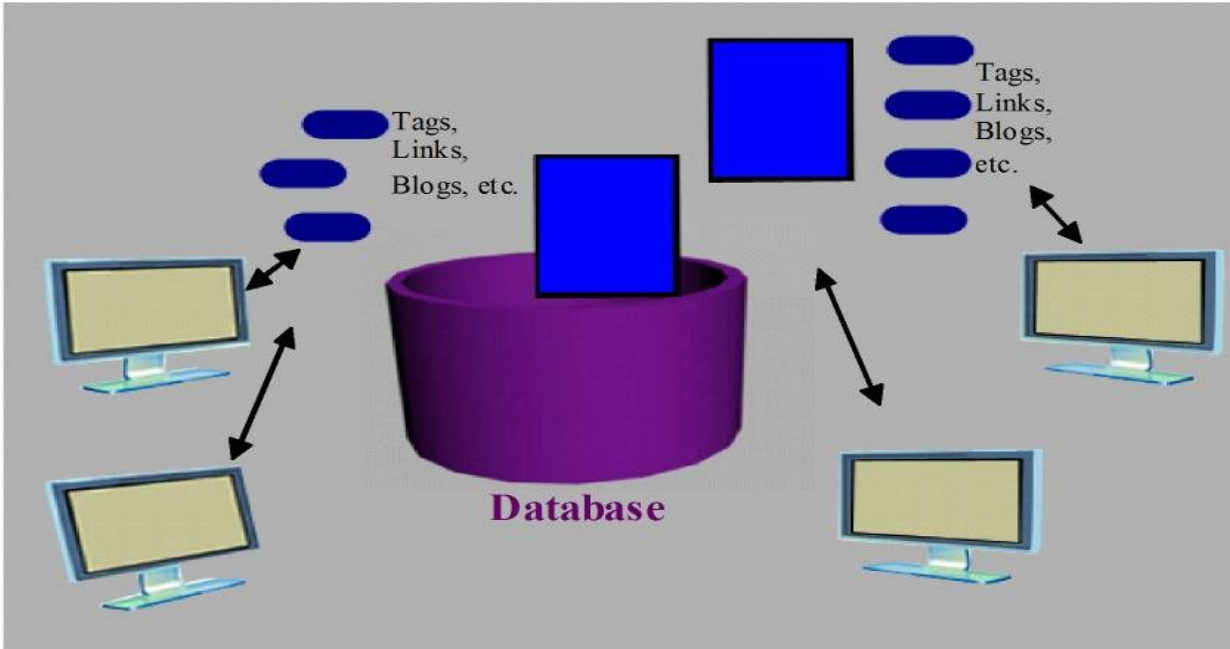
animation, is a powerful communication medium, and makes collaborative work easy. Sasada investigated and presented the demonstration of how the technologies, joined with computer graphics through networking, solve problems of three dimensional designs in the architectural design process (SASADA, 1995).

- - The concept of "Open Development Environment" was introduced within designing even before employing the Internet and Networking (FUKUDA, NAGAHAMA, and SASADA, 1997). Open Development Environment is an approach to allow various people separated by great distances, to work together on a given project and to introduce computer simulation into the working environment.

### First Phase, File Sharing



### Second Phase, Source Sharing



### Third Phase, Source Sharing through an Agent

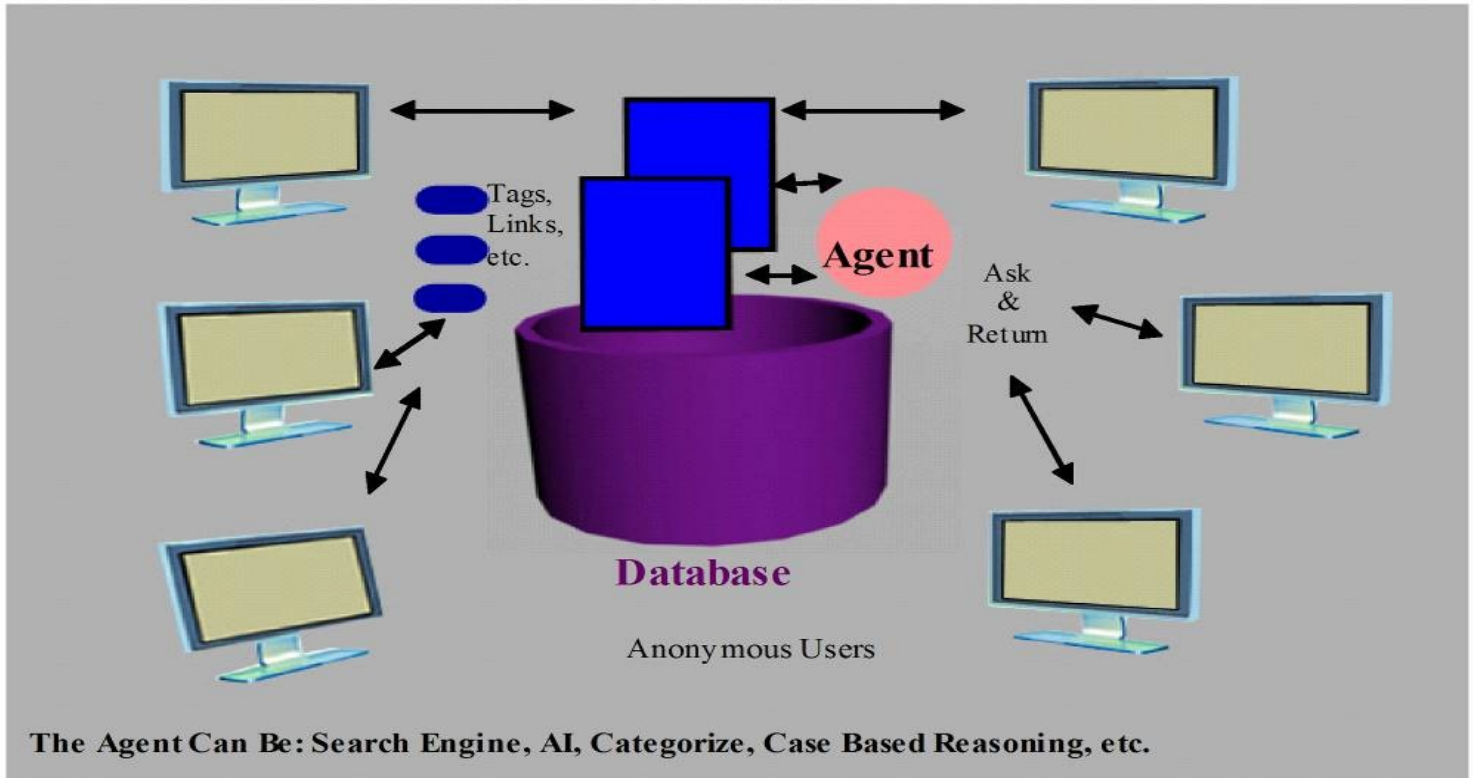


Figure 1 Development and Classification of Knowledge Sharing through Networking

## 2.2. Source Sharing

Concept of sharing a source allows a group of people to download and upload files from a certain database through the same network. Architectural design and Urban Planning require specialized visual knowledge that goes beyond the sharing of marks on paper or the multi-casting of video images. Applications of networking as a powerful design medium, thus, were acknowledged and implemented to fulfill the requirement and nature of designing. Of accomplishments in this classification are:

- **Design education**

Elger and Russell (2000) presented a Net-Studio that is a virtual design studio where the environment for presentation, criticism and communication is web based. This allows lessons learned from research into computer supported cooperative work to be adapted to the special conditions indigenous to the architectural design studio.

Lindquist (2006) investigated the suitability of Wikis for enhancing student collaboration in the site analysis and preliminary design stage of a project, within a landscape architecture design studio. The Wiki was used to collect, compile and present data for the purpose of a precedent study of cultural and physical analysis in which the technology proved successful. However, the Wiki according to her was less successful in contributing to the collaborative preliminary design of the project (LINDQUIST, 2006).

- **Networking**

- - In a distinguished contribution, Richens and Trinder (1999) introduced a shared computer research and teaching laboratory between Cambridge University and Microsoft, which uses internet based communication between clients and their architects, including email, a web site and virtual reality (RICHENS and TRINDER, 1999).
- - Jung, Do, and Gross (1999) presented a working prototype of a system that has the capabilities of allowing designers to embed annotations and proposed design changes in the three dimensional design model under discussion. In their research work, they introduced the 'Redliner' which lets design team members browse and leave text annotations on surfaces in three- dimensional models. They developed their research further in 2001 and 2002 introducing 'Space Pen' an annotation system with improved interaction capabilities that goes beyond the post. It allows users to draw in and on the virtual environment, and three dimensional web models (JUNG, GROSS, and DO,

2002).

- - Yamashita et al. (2006) developed a collaborative design environment which considers Information and Communication Technology and architectural space, through supporting synchronous design collaboration in a face-to-face meeting at a local site and also in a continuously connected project-room at distributing sites (YAMASHITA et al., 2006).
- - Lan and Chiu (2006) demonstrated a Web 3D-GIS approach to develop the urban information system. Lan and Chiu proposed that a digital city should be able to not only visualize a large-scale 3D city model but also integrate useful urban information for potential users' retrieval in a web environment (LAN and CHIU, 2006).

### **2.3. Source Sharing through an agent**

Allowing source-sharing process between anonymous users through the Internet, rather limited users of certain networks, highly improves the process. In addition to, using an agent in the source-sharing concept enhances its applications where users can acquire certain kinds of data through this agent, and then the agent collects and returns the required data to them. The agent can be presented through different approaches, such as: Search Engine (Yahoo, Google, etc.), Artificial Intelligence, Categorizing, and Case Based Reasoning (CBR).

There are different applications and implementations of this classification, such as:

- - Heylighen and Neuckermans (2000) introduced the development and use of a Web-based design tool called DYNAMO. It is filled with a permanently growing collection of design cases that is accessible on-line. Its objective is to initiate and nurture the life-long process of learning from design experience, as suggested by the cognitive model underlying Case-Based Design approach, and Case-Based Reasoning in general (HEYLIGHEN and NEUCKMANS, 2000).
- - Shih (2003) introduced a web-based agent framework to support communication, to facilitate shared understanding amongst the participants and to inspire teamwork. This communication framework, based upon a web agent, provides an intelligence distribution opportunity for the architecture, engineering and construction industry to introduce a new and innovative paradigm of collaborative design (SHIH, 2003).
- - Matsumoto, Kiriki, Naka, and Yamaguchi (2006) proposed the collaborative design education program on the web, and developed the special Design Pinup Board system for running it. The introduced program according to Matsumoto focuses on



very limited environment; distributed collaboration beginners, asynchronous, first meeting, and plural teams (MATSUMOTO et. al., 2006).

## **Design forum**

In design forum area researchers introduce various applications, for example:

Zhang, Tsou, and Hall (2001) proposed a city map that is managed by a specific database management system (DBMS) on the server side. Users may retrieve information for various modification simulations, where the system automatically remodels the virtual environment to respond to users' requests (ZHANG, TSOU, and HALL, 2001).

In another contribution, Lee (2001) maintained the possibility to create a 3D modeling tool based on the recognition of labels in freehand sketches, and introduced a symbol-based 3D modeling tool (the SpaceMaker) that allows designers to make freehand floor-plan drawings to explore the initial concept of spatial layout and allows users to apply labels to identify different types of space (LEE, 2001).

Oh and Kidawara (2006) developed a network management device that makes it possible to acquire embedded content using coordinated ubiquitous devices. A prototype system was described, which can share 3D objects in a virtual 3D space based on a real-space environment. The introduced system can be used not only as a virtual 3D browser in a private area, but also as an interactive digital poster in a public area (OH and KIDAWARA, 2006).

## **2.4. Business and commercial use**

The Internet potentials and the associated concepts previously discussed have been used in various business and commercial applications. Consequently, further accomplishments of more possible have been achieved. Of these accomplishments are: Wiki, Web 2.0, Youtube, Second Life, Social Networking Service, etc.

### **Wiki concept**

A wiki is a website that allows visitors to add, remove, edit and change content, typically without the need for subscription. A wiki is an effective tool for mass collaborative authoring through this easiness of interaction and operation among its visitors.

There are various applications of Wiki, for example:

- Lost Garden 'Viki', its URL address is <http://lostgarden.com/2007/05/viki-visual-wiki-design.html>. A Viki in its most basic incarnation is a visual wiki. Instead of creating pages of words that are hyper linked together, the users through Viki create pages of images that are hyperlinked together. It acts as the ultimate sticker book mash up.

## **Web 2.0**

The phrase Web 2.0, introduced in 2004 by O'Reilly Media, refers to a perceived second generation of internet-based services (such as social networking sites, wikis, communication tools, and folksonomies) that emphasize online collaboration and sharing among users.

According to Tim O'Reilly "Web 2.0 is the business revolution in the computer industry caused by the move to the internet as platform, and an attempt to understand the rules for success on that new platform." (<http://dx.doi.org/10.1016/j.serrev.2007.05.001>).

## **Youtube and Flickr**

Youtube (<http://youtube.com/members>) is famous as a video sharing website using Ajax, which is one of the technologies of Web 2.0. It was launched in 2005, and 100 million movie clips are viewed daily on the site in only a year. The site is ranked as the 5th most popular website in 2006. (Wikipedia – YouTube) This is the typical example to success on sharing a huge amount of data in a short time.

Flickr is an image sharing web site. User can add any tag information to the images for helping on searching images. FOLKSONOMY is considered as the biggest advantage of this service (<http://www.folksonomy.org/>). The site is using Web 2.0 through AJAX that stands for Asynchronous JavaScript and XML.

## **Second Life**

Second Life is a 3D virtual world entirely built and owned by its residents. Second Life was opened to the public in 2003. Since then, it has grown explosively and nowadays is inhabited by a proximate total of 5.5 millions people from around the globe. By entering the world of Second Life, the user will discover a vast digital continent, teeming with people, entertainment, experiences and opportunity. Users may find a perfect parcel of land to build a house or business. Because residents retain the rights to their digital creations, they can buy, sell and trade with other residents. The Marketplace currently supports millions of US dollars in monthly transactions. Another example related to the

same approach is Massively Multiplayer Online Role-Playing Game (MMORPG) Ultima Online that was created in 1997 ([www.secondlife.com](http://www.secondlife.com)).

### **Social networking service SNS**

This approach is represented in many applications, such as: Myspace, Hi5, and Facebook, where each user has a source of different files (general profile, friends, interests, photo albums, etc.) Only can the persons in his/her contact list view and share these files with the user. Others may be allowed to only view the main file of user's source (general profile). Another example related to the same approach is Public Participation GIS, PP GIS, (<http://ppgis.iapad.org/>).

### **3. DESIGN WIKI**

Applying networking in designing through the three introduced concepts, anonymous users can use Design Wiki website in various applications. This part of the research is concerned with illustrating the system uniqueness, methodology, functions and applications, and case studies through the introduced functions of the system.

#### **3.1.Design Wiki uniqueness**

What distinguishes Design Wiki from previous research, and business and commercial use? All the previous researches and applications have the following significances: 1) implement networking in design discipline, 2) easy to understand, 3) allow editing (change and delete), 4) add comments and critics to the existing source, and 4) create a new business model and potentially create profits through some commercial use.

Web 2.0 is an important key to spread the community for data sharing. While Youtube is Video Sharing, Flickr is Image Sharing, and SNS is Social Networking Service, spreading through Networking and Forums.

Second Life that its unique function is to allow changing the virtual money to the real money has its copy right and ownership used in the virtual world. Nevertheless, Second Life that may appear as more related to our Design Wiki, is categorized into a kind of an online game.

However there is no research or commercial use to effectively share designs, to clearly arrange and link the saved designs, and to easily modify and present designs through visual database. Design Wiki innovatively implements these requirements and objectives through its significances that can be summarized in the following:

- Using a 3D modeling system tool, with a simple modeling approach that its transformations and changes of form assembling can be easily recognized through only one-simple-step change of form at a time.
- Sharing designs effectively through/in a visual map of 2D and 3D designs database.
- Applying functions of searching (zoom in and out), and modifying (create, edit and delete).

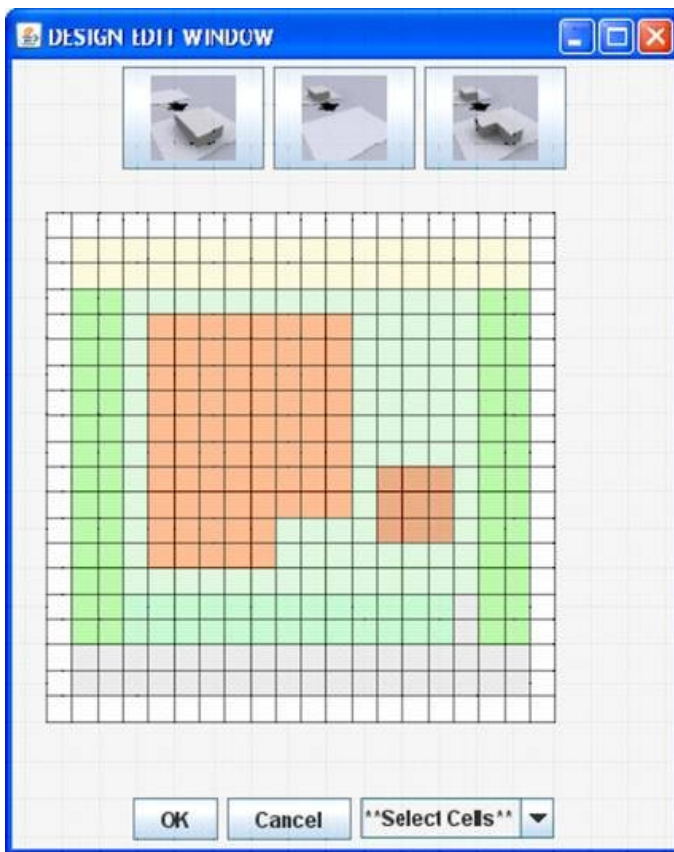
### 3.2. Methodology

The Design Wiki is implemented in Java, and tested using a free Enterprise Internet Portal Framework, JetSpeed2 (by Apache Portal Project site, <http://httpd.apache.org/>). It is programmed as a Portlet that can be run under any kind of Portal application. Three main Portlet programs are in a Portal Application; the applied methodology employs the three concepts of Wiki Design:

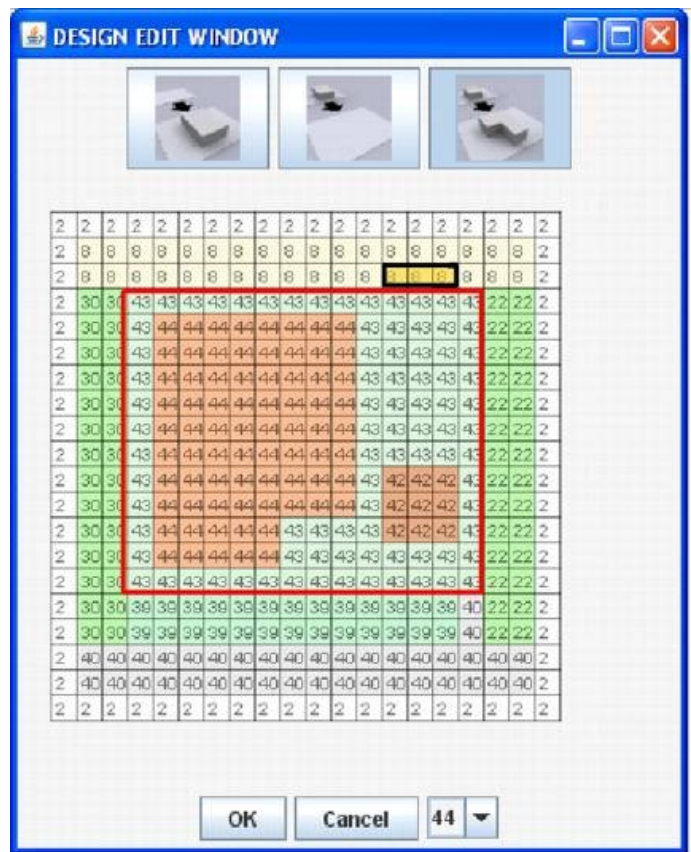
**1) Simply generating 3D object by 3D modeling system**, the modeling system, KISS modeling (ABDELHAMEED and KOBAYASHI, 2007), applies the rule of (Keep It Simple, Stupid), Figure 2. The simplicity of this modeling system is to not only attract a large number of designers to the online community, but also present the methodology, functions, and ways of creation and modifying.

The motivation of using KISS rule in a modeling system is to apply only one simple rule at one step any user can follow it up. Other modeling systems computationally applying a combination of many rules to have different transformations in one step may have outputs that can not be easily linked to the original design (input). The proposed modeling system, focusing on presenting forms' topologies and modifications, leaves the immaterial issues of designing for users to conceive and interpret.

KISS Modeling utilizes space layout data to produce three dimensional forms. Space Layout Data is a set of spaces in two dimensions or three dimensions. The system has two modes. One is to show all the designs in a designs layout. Each design is represented as a node with linked lines to its parent design. The other mode is to create a new design from an existing one.



a



b

Figure 2, a shows a displayed 2D design with the three buttons of modifying (create, edit and delete). b shows the same design after modifying by adding the three cells outlined

**2) Sharing the designs in a visual map**, users share in creating, editing, and deleting all the designs presented in the database (KOBAYASHI and ABDELHAMEED, 2007). The processes are:

- Initial Condition: The user has to prepare two files; an initial space layout file and a file of space property list. The file of Space Property List has the adjacency list of a design, for example in Figure 2 b, the adjacency list for 43 is: 8, 22, 40, 39, 30, and by changing the three outlined cells to a new space, e.g. 45, the list will be: 8, 45, 8, 22, 40, 39, 30. The Space Layout file should have at least one design with an array of 400 (20x20) integer numbers such as (0 0 0 0 1 1 1 ... 0 0 0). Each integer number represents a space property such as 0=Street, 1=Sidewalk, and 2=House, which are defined the file of space property list, Figure 3.

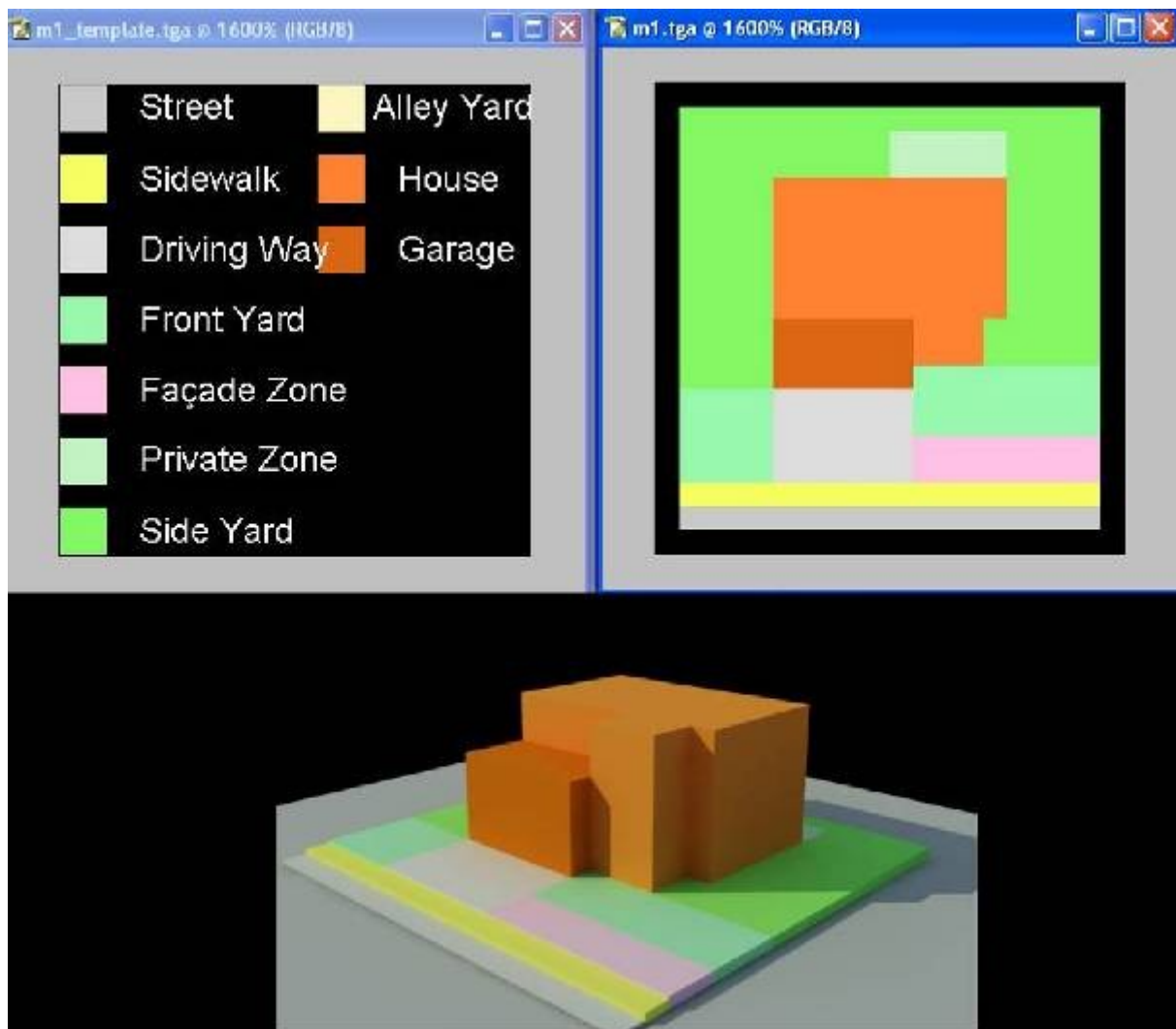


Figure 3, A design displayed in 2D and 3D with a space list

- Add Design: The user can add a new Design from one existing one in the map, Figure 5 (KOBAYASHI and ABDELHAMEED, 2007). First, the user selects one exiting Design as a parent design. Then, the editor panel to modify the design pops up. The modified design is checked if it can be a new Design or a Subspecies by calculating topological changes. If it is a new Design, the layout is posted on DesignMap with a link to the parent design. Otherwise, it is registered as a Subspecies and shown under the parent design.
- Delete Design: The user can delete any design in DesignMap. As Wikipedia allows any user to add, modify and delete any contents, DesignMap has the same concept and functions.
- Generating 3D models: DesignMap provides only the list of space layout designs, Figure 3. The other Portlet provides a list of generation files, which any user can post the file to generate 3D models from any space layout design in DesignMap, Figure 4 (KOBAYASHI and ABDELHAMEED, 2007).

**3) Topological constraints for defining the space layout domain,** a special rule was created to check if a new space layout design can be a new Design or be a Subspecies.

The rule is as following:

- Calculate the adjacency list for each space. If a space whose ID is 1 is adjacent to space 2, 3, and 4, the adjacency list will be (2, 3, 4), as previously illustrated in Figure 2 b.
- By modifying the design layout, if the adjacency list does not change, the output is registered as a subspecies. Otherwise, the design is considered a new Design.
- In the previous process, if the adjacency list is changed with more than two items at the same time, the modified design is not allowed to be added to the Map. The user will be able to add the design to the map, only when an additional design with one item changed is added before it.

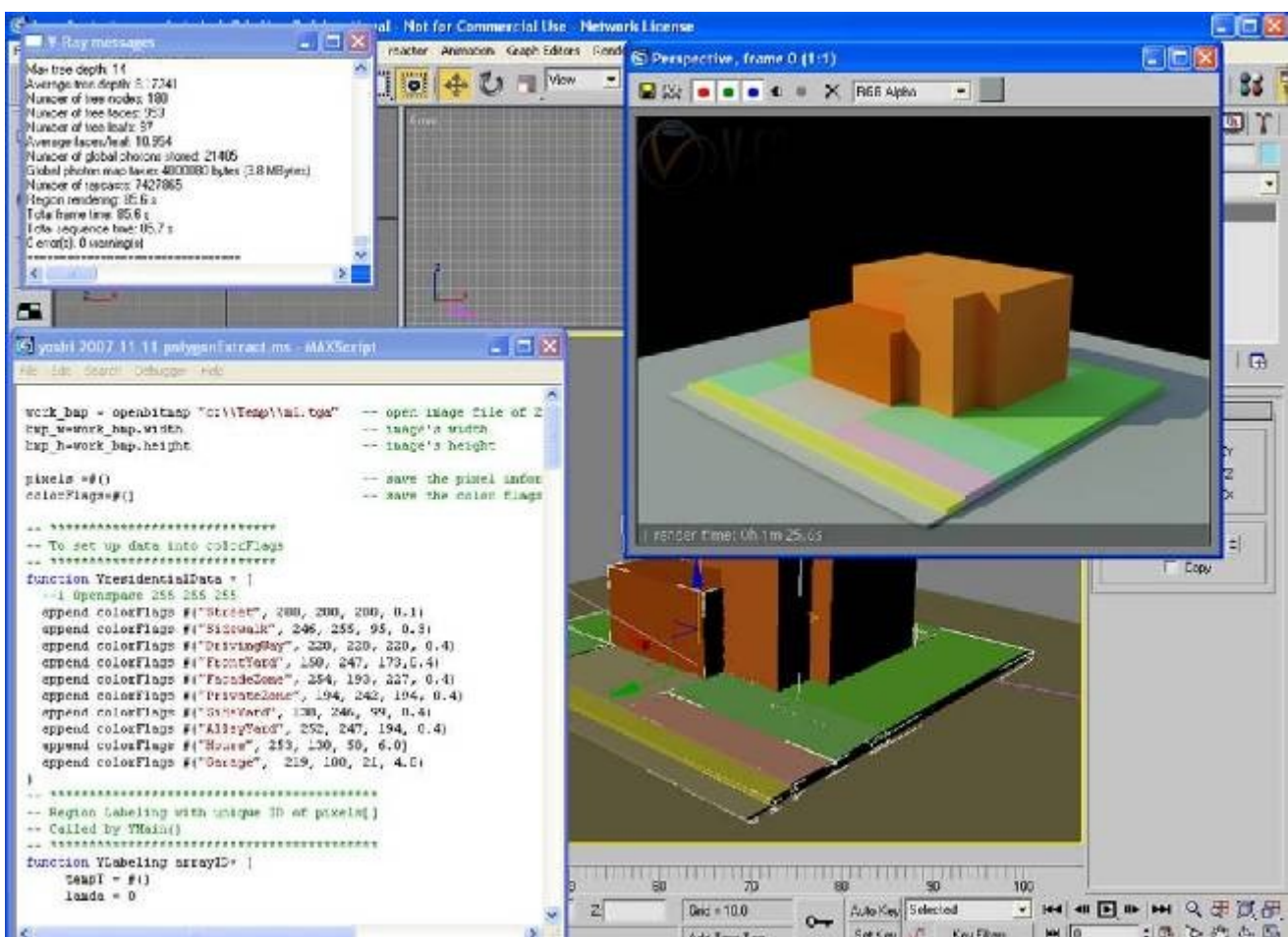


Figure 4, Process to present a design through defining the space layout domain by scripting (3ds max)

### 3.3. Functions and applications

The system functions and applications are classified into the presented portlet programs, namely Wiki design, KISS modeling, and design map, Figure 5.

Each design is represented in a node, where a new design can be generated and then added to the layout by the users when a new set of objects or a new condition of objects

relationship is created from the original design. The designs are created and modified through the introduced 3D Modeling System.

Moreover, the introduced forms into Design Wiki can be employed as initial designs in architecture and urban planning. These initial designs therefore can be applied in various disciplines and mainly within the area of Design-Ideas Alternatives inside the design process. The offered functions facilitate processes of altering and adding new designs modified from the designs previously saved.

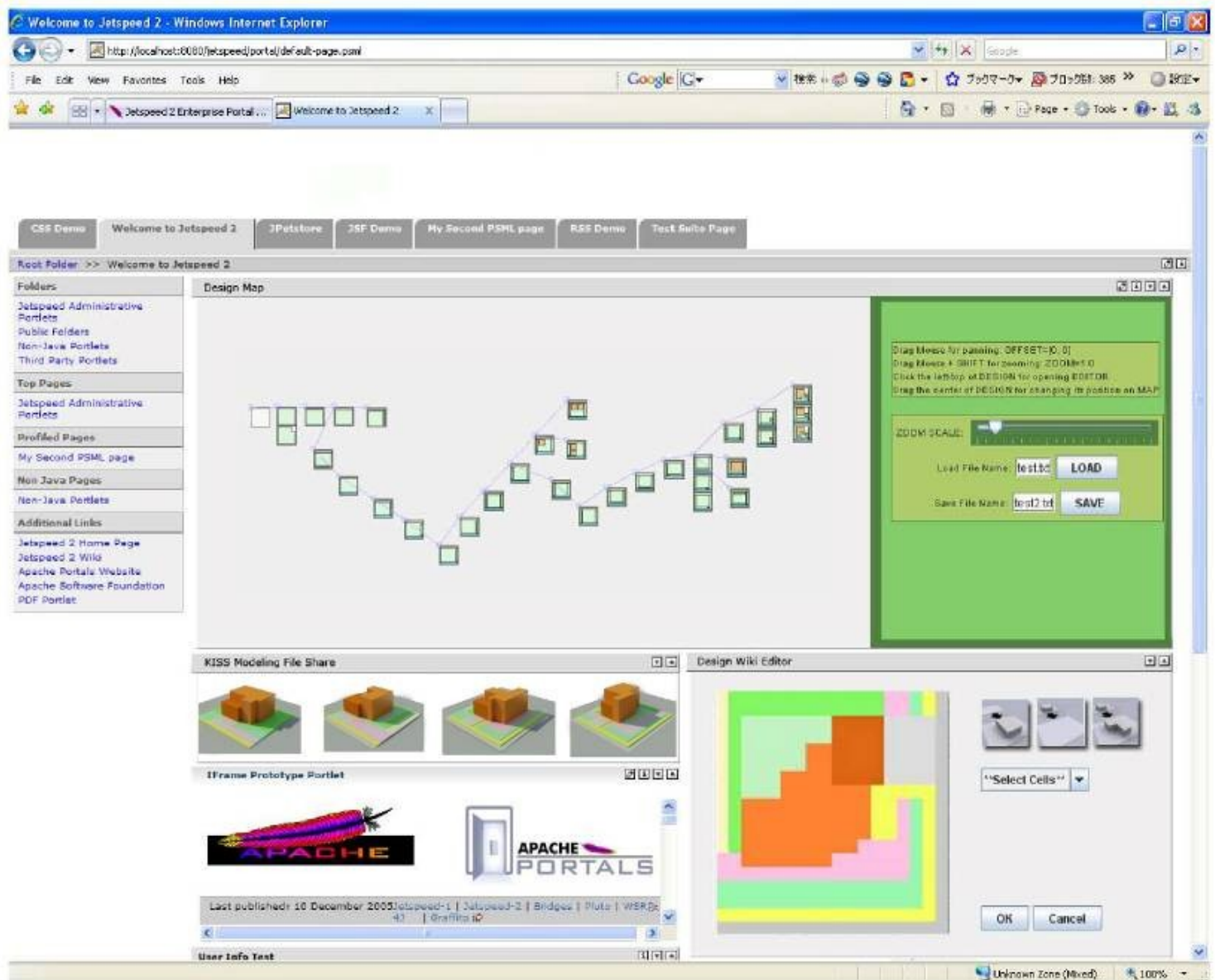


Figure 5, The Main Webpage of the Design Wiki System that has the three Portlet Programs. Designs are Represented in Nodes in Design Map Portlet

### - Wiki design portlet:

In this portlet implementation, three main objects are defined: Space, Design and Subspecies. Space is a class of a list of cells occupying in a grid. Design is a class of a list of spaces, and is represented as an individual node in the designs layout. Subspecies is a



class not for a new design but for the design whose topology is not changed from the parent design. A new design is generally generated when a new set of spaces or a new neighborhood of conditions is created from its parent design. For example, when the size of space is changed without changing any relations to neighbor spaces, a new design is not generated but a subspecies is. The lists of all spaces, designs, and subspecies are saved in a separate file.

### **- KISS modeling portlet:**

KISS modeling portlet has three functions stages, i.e. Input, Middle Ware, and Output. Input is space layout design; Middle ware is recognition file (KISS file); and Output is 3D models and rendered images.

### **- Design map portlet:**

Design series sharing in Portal Application is implemented through the following:

- Create network application to share designs among any number of users all over the globe, presenting a design Wikipedia.
- Processes of search, analyze, and categorize, are made without words but through designs (a set of spaces) as design is beyond the words. Topology is the main item used to implement these tasks.

### **- System products and case studies**

Products and case studies that are created through the portlet of the main webpage of the Design Wiki system, Figure 5, present the main functions of the proposed modeling system. In short, the process to generate 3D model is as follows: 1) select one design, multi designs or all designs in DesignMap, 2) select or create generation rules, 3) 3D model is generated for each selected design, and 4) the generated models are saved as 3D formatted files. Detailed example products of KISS modeling are displayed in Figure 6, through a file that can be uploaded in the Design Wiki system to either add a new design or modify an existing design.

By changing the properties of cells in the portlet's grid, a new space is created. A space is defined as a set of cells with the same property such as house, front yard, driving way, and garage. As a result, a design with a new space is registered in the system and update the DesignMap.

## **4. CONCLUSION**

The paper introduced state-of-the-art in areas of Networking, Online Community, and Forum, in order to have a comprehensive basis to present a novel system for design sharing applied in a networking design database.

Applications and future work for the presented system, including its three main concepts of: KISS modeling, DesignMap, and Wiki Design, can be implemented in various areas of architecture and urban planning, e.g. design process, design education, design projects execution, project management, etc.

The contribution of our system, Design Wiki, manifests itself through the possibility of being applied in many design areas, one of which is the design studio that is the concern of a research in progress conducted by the researchers. In design studio, students may start adding their initial designs to the system at the studio start, and continue the adding process at each modification made. The system arranges students' designs in series. Design Wiki helps not only students in their design processes but also instructors in tracking students' modifications and in educational methods applied in the studio. Other design areas such as urban design and urban planning can also benefit of the Design Wiki system.

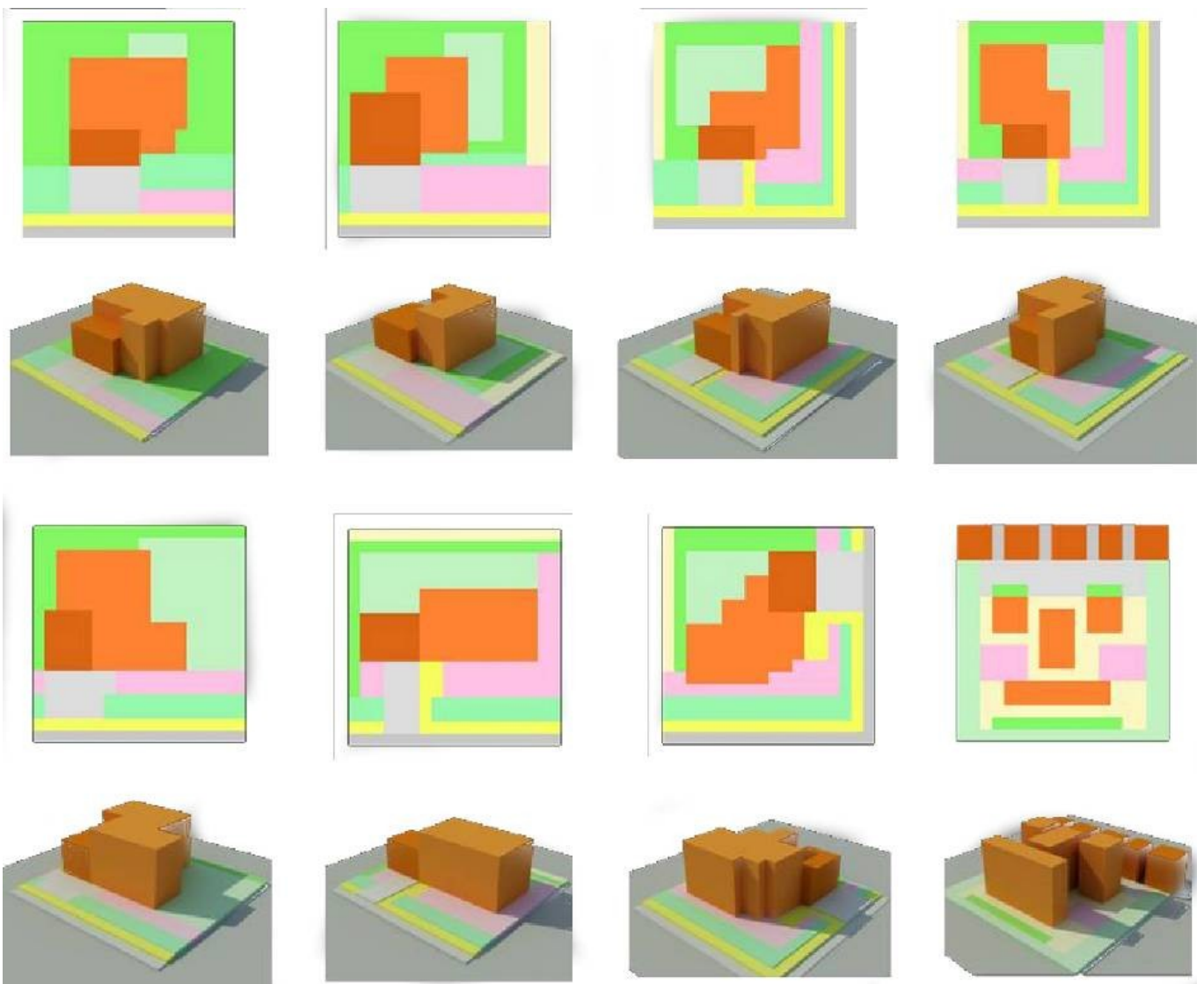


Figure 6, Different Products through Using KISS Modeling Portlet and Design Wiki Portlet in the Design Wiki System

## References

1. LEE, Ming-Chun, SpaceMaker: A Symbol-based Three-dimensional Computer Modeling Tool for Early Schematic Development of the Architectural Design, M.Sc. Thesis, Design Machine Group University of Washington, Washington, 2001.
2. HEYLIGHEN, A., CASAER, M., and NEUCKERMANS, H., Unaware: Supporting Tacit Design Knowledge Exchange, International Journal of Web-Based Communities, 2006, 2 (1), pp. 31-44.
3. RICHENS, P. and TRINDER, M., Design Participation through the Internet: A Case Study, Architectural Research Quarterly, 1999, 3 (4).
4. ABDELHAMEED, Wael and KOBAYASHI, Yoshihiro, Developing a New Approach of Computer Use 'Kiss Modeling' for Design-Ideas Alternatives of Form Massing: A framework for three-dimensional shape recognition in initial design phases, Proceedings of the 3rd Conference on ASCAAD, Alexandria Bibliotheca, Alexandria (Egypt) 28-30 November, 2007.

5. ELGER, D. and RUSSEL, P., Using the World Wide Web as a Communication and Presentation Forum for Students of Architecture, Promise and Reality: State of the Art versus State of Practice in Computing for the Design and Planning Process, Proceedings of the 18th Conference on eCAADe, Weimar (Germany) 22-24 June 2000, pp. 61-64.
6. FUKUDA, T., NAGAHAMA, R. and SASADA, T., Networked Interactive 3-D design System for Collaboration, Proceedings of the CAADRIA Conference, Taiwan, 17-19 April 1997, pp. 429-437.
7. HEYLIGHEN, A. and NEUCKERMANS, H., DYNAMO in Action - Development and Use of a Web-Based Design Tool, in: Pohl, J. and Fowler, T., eds., Proceedings of the Focus Symposium on Advances in Computer-Based and Web-Based Collaborative Systems - InterSymp-2000 International Conference On Systems Research, Informatics and Cybernetics, Baden-Baden (Germany), July 31 - Aug 4, 2000, pp. 233-242.
8. JUNG, T., GROSS, M., and DO, E., Annotating and Sketching on 3D Web models, Proceedings of the 7th international conference on Intelligent user interfaces (IUI'02), San Francisco, California, USA, 13-16 January 2002, pp. 95 - 102.
9. JUNG, T., DO, E., and GROSS, M., Immersive Redlining and Annotation of 3D Design Models on the Web, Proceedings of the 8th International Conference on CAAD Futures, 1999, pp. 81-98.
10. KOBAYASHI, Yoshihiro and ABDELHAMEED, Wael, Design Map: a framework for a design environment through networking, Conference Proceedings of Sigradi 11th, Mexico, 23-25 October 2007.
11. LAN, U-H. and CHIU, M-L., A Web 3D-GIS Approach to Develop the Urban Information System of Virtual Anping, Proceedings of the 11th Conference on CAADRIA, Kumamoto (Japan) 2006, 479-486.
12. LINDQUIST, M., Web Based Collaboration (for Free) Using Wikis in Design Studios, Synthetic Landscapes, Proceedings of the 25th Annual Conference of ACADIA, 2006, pp. 190-199.
13. MATSUMOTO, Y., KIRIKI, M., NAKA, R. and SHIGEYUKI Y., Supporting Process Guidance for Collaborative Design Learning on the Web: Development of "Plan-Do-See cycle" based Design Pinup Board, Proceedings of the 11th Conference on CAADRIA, Kumamoto (Japan) 2006, pp. 71-80.
14. OH, S. and KIDAWARA, Y., A real-space navigation system based on ubiquitous technology, Communicating Space(s), Proceedings the 24th Conference on eCAADe, Volos (Greece) 6-9 September 2006, pp. 618-625.

15. SASADA, T., Computer Graphics as a Communication Medium in the Design Process, Proceedings of the 6th International Conference on CAAD Futures, Singapore, 24-26 September 1995, pp. 3-5.
16. SHIH, S-C., A Web-Based Agent Framework for Collaborative Design-Build Communication, Proceedings of the 8th Conference on CAADRIA, Bangkok (Thailand) 18-20 October 2003, pp. 55-68.
17. YAMASHITA, S., YOSHITAKA M., YUJI M., RYUSUKE N., and SHIGEYUKI Y., Enhanced and Continuously Connected Environment for Collaborative Design, Communicating Space(s), Proceedings the 24th Conference on eCAADe, Volos (Greece) 2006, pp. 478-485.
18. ZHANG, Z., TSOU, J.-Y., and HALL, T., Web-Based Virtual-Reality for Collaboration on Urban Visual Environment Assessment, Proceedings of the 9th International Conference on CAAD Futures, Eindhoven, 8-11 July 2001, pp. 781-794.
19. <http://lostgarden.com/2006/05/viki-visual-wiki-design.html> [23-10-2009].
20. <http://dx.doi.org/10.1016/j.serrev.2007.05.001> [23-10-2009].
21. <http://youtube.com/members> [23-10-2009].
22. <http://www.folksonomy.org/> [23-10-2009].
23. <http://www.secondlife.com/> [23-10-2009].
24. <http://ppgis.iapad.org/> [23-10-2009].