COLLABORATIVE CAD MODELING PROCESS ANALYSIS TO SUPPORT TEAMWORK FOR BUILDING DESIGN

ANÁLISE DO PROCESSO DE MODELAGEM COLABORATIVA EM CAD COMO SUPORTE AO PROJETO DE EDIFÍCIOS EM EQUIPE

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ABSTRACT

Collaborative tools are information systems which allow document sharing through local area networks, intranets and extranets. Collaborative design can be a solution to increase the productivity and the final quality of the product in a building design office. In this way it is possible to assure the information integration and also the data integrity during the design process based on computer network communication. The goal of this article is to analyze how one CAD system based on BIM concept (ArchiCAD software - Graphisoft/Nemetschek) can support a collaborative teamwork structured on an integrated model for different design views. In this model, the tasks are assigned by a coordinator and executed by the designers in different places following the client-service scheme. It is intended to contribute with the diffusion of this information technology tool and to present its potentiality for the improvement of the design performance. The research method used was a case study of the development design. In this case study, communication guidelines had been applied to verify the software behavior in relation to the task execution in a shared framework. The use of the collaborative CAD modeling in the development design provided information sharing, track and control of document versions and also the integration of design modifications in such automatic and simultaneous way between different computers used.

Keywords: Building information modelling; collaborative teamwork; workflow.

1. INTRODUCTION

Since the beginning of digital age, new technologies have influenced people in different ways, in which life is not anymore as before, and the knowledge worldwide has become more accessible. However, as there are continuously more perspectives and opportunities, people are meeting problems never existed before the digital age. The digital age has created new challenges and given people tools with which the working methods have changed. Architecture is still searching for its own position with the use of computers in designing. The evolution of computer aided architectural design can be viewed through the generations of CAAD (Reffat, 2006). The first generation of CAD systems can be called as "computer aided drafting". The primary objective of the first generation of CAD technology was to automate drawing and produce simple drawings by assembling several shorts lines to create simple objects. CAD technology allowed drawings to be created and stored in an electronic format but it did not recognize construction and building elements. Therefore, printed drawings were interpreted by users in the same way as manually prepared documents. The second generation of CAD technology was introduced in the 1970s and it was concerned with developing a mathematical description of the geometry of an object. Thus, this generation of CAD technology enabled users to produce three-dimensional visualization of a building. The third generation of CAD technology was introduced in the late 1980s and the primary purpose was to integrate geometric information with non-geometric data through the establishment of associative and parametric relationships between them (Kale & Arditi, 2005).

This third generation of CAD technology is recognized by the term "Building Information Modeling (BIM)". BIM is the process of generating and managing building information in an interoperable and reusable way. Thus, through a BIM model it is possible to integrate and reuse building information and domain knowledge through the building lifecycle (Lee et. al., 2006). In the marketplace there are a lot of CAD products which are based in the BIM concept, such as: Nemetscheck Allplan; GraphiSoft ArchiCAD; Autodesk Revit.

In the conventional design process (here expressed as the first and second generation of CAD technology) it is created a series of technical drawings without explicit connections between them. The reading of all these elements permits the understanding of all design information. The set of drawings can consequently lead to a virtual model – a three-dimensional model that allows better viewing of the information, but that hardly influence in the design process and in the product final quality (SPERLING, 2002).

In the process using BIM technology the designer "build" virtually a building model through objects that simulate the behavior and shape of constructive elements. The virtual models can be understood as databases, where are stored both geometric data and text information of each construction element used in the design. The combination of this data enables automatic extraction of documents such as plants, sections, perspectives and quantities take-off. The designer's attention is aimed primarily at design solutions, and not to technical drawings, which are in large generated automatically by the computer (BIRX, 2006).

However, the use of BIM CAD is emerging new working methods for design process which should be studied and demonstrated to its widely adoption. Therefore, the goal of this paper is to present an experience of an architectural design development with virtual collaborative design team supported by a BIM CAD (ArchiCAD/Graphisoft) technology. Through the carrying out of two case studies will be demonstrated the main drawbacks and advantages for the collaborative design supported by a BIM CAD (ArchiCAD/Graphisoft) technology.

2. RESEARCH METHOD

The research method used was exploratory case studies. These studies allowed rate the integration of teamwork in the development of design production. For the method was established communication guidelines with some attributes that helped the administrator and team leader in the early decision making before the beginning of the design development.

This communication guidelines has been divided into three stages. The first was that the requirements of communication where the administrator defines the team

that will design develop and all necessary requirements. The second phase was the distribution of information, where the team leader distributes tasks to each involved in the design. As the design is being developed should be a continuous control which has been suggested as a third step. To better understand this communication guidelines, in the chart 01 follows every step and the needs that have been suggested in each one.

STEPS	NEEDS
Communication Plan	**Requirements:** 1- Determine the team for the design development. 2- Determine who will be: • the administrador, • the team leader, and • the teammates.
	Definitions: 1 - All involved in the project must have the same configuration to design development. 2 - The team leader together with the administrator should check before start to distribute information: • Design Preferences: Dimensions, Calculation Units, Construction Elements, Zones, Layouts, Miscellaneous, Scale, Layers,
	Involved and their responsibilities: 1 - Determine for each involved person their activities: • Determination through Layer
	Creating icons to mark up: • In check, check, awaiting approval, approved.
Distribution of information	1 - Distributing information to everyone involved in design.
Control	**Verification:** 1 - Check the conformities with the proposed design of this running 2 - Check if those involved in the design are fulfilling the tasks intended

Chart 01: Communication guidelines

For this search was conducted one pilot test and two case studies in a structured design office by authors of article to expand the search. In all studies, as well as test pilot, the working group was composed of three members. These members alternate roles between the administrator, team leader (which have been made by the same professional) and the teammates during the pilot test and case studies. The test pilot was prepared in order to remedy any possible loopholes which could be in the plan, as well as throughout the design development using ArchiCAD

system. Most errors that occurred during the pilot test were that teammates received messages from the team leader in the "mark up" but does not change the status for verification. Therefore, the team leader did not know how the teammates had seen or received the message or not. Furthermore as the program does not notify the receiving messages, the whole team should look at the "mark up" from time to time.

3. COLLABORATIVE DESIGN TOOLS OF ARCHICAD/GRAPHISOFT

ArchiCAD from Graphisoft offers tools to allow designers work simultaneously on the same design through a functionality called "Teamwork". To use this function, it is necessary first set up a shared ArchiCAD project. These settings include: design scale and measurement units; stories and layers; attributes (pen colors; line and fill types; composites; materials); grids and display options; and, active libraries. A design team using the collaborative tools can be organized throughout different ways. Then, it is possible to use rigorous sets by defining strict hierarchical access privileges in large offices or it is possible to leave more freedom setting in smaller practices, where the team working is in face-to-face contact. There are five possible roles in teamwork: Administrator; Team Leader; Teammate; Mark-up and View Only. The first two have to be defined in advance by the person sharing the design who can either allow free access by any teammate or set up strict access through passwords (ArchiCAD, 2007).

After the basic settings have been defined, the design is shared by its administrator and then the teammates can sing-in to the project. When signing in the team members need to reserve a part of the design and then they will have the private right to work on this part as long as they keep this reservation. Thus, ever single element of the design either belongs to a specific teammate or none of them. Updates to the design are done through "sending and receiving changes" function, but the changes are only visible in other teammate's copies if they choose the "Receive Changes" command. The revisions and the communications between designers can be supported by the "Mark-up tool". It allows the designer to point out problematic elements with a color highlight, correct and manage colleague's errors and make alternative design suggestions. In order to do these tasks, it is

necessary to assign the revisions to a responsible for the task. In this way, every time a sign-in is done by a teammate, an advice about the new task will be displayed and the teammate will have the option to accept or leave out the assigned task. The management of the assigned tasks is done by the team leader and the status of each entry is controlled through the "Mark-up styles", which determines the progress each entry. For instance: revision, in progress, closed, approved and remarks. The communication between designers is also supported by the "Mark-up tool". Thus, it is possible to add comments in order to clarify the assignments of the tasks, especially for large teams where face-to-face discussions are not possible (ArchiCAD, 2007).

4. TEAMWORK

The teamwork tools of ArchiCAD enable greater integration between the team of architects and other professionals involved in the design development project. In addition, they provide some rules and hierarchy for the organization of design team. The teamwork defined by the ArchiCAD is composed of professionals as design coordinator, senior architect, and other professionals as follows. The administrator and team leader can be characterized with the office design coordinator through the senior architect. According Lamoréa et al. (2007) to coordinate services to ensure that the technical solutions are developed by designers from different specialties. In both case studies with ArchiCAD (2007), the professional involved in activities of the administrator and the team leader was the senior architect. According AsBEA (2000), the architect is who has the best conditions to act with adequate performance in a team coordination function because throughout the process this professional is always in contact with the professionals of other areas. Silva Souza (2003) establishes some features necessary for the design coordinator:

- identification and characterization of technical interfaces to be resolved;

- establishment of guidelines and technical parameters of the venture from the product characteristics of the production process;

coordination of the information flow among the team members for the development of parts of the design;

- review of technical solutions and the degree of global settlement reached;

- making decisions on the solution integration needs.

In AsBEA (2007), the senior architect must have a good experience in design development, knowledge and operation of CAD, and team progress coordination, as well as proposes solutions to technical problems, participates in meetings, and visits the site works. The teammates are part of the design team and can be junior architects and full architects can be the designers or office designers.

5. FIRST CASE STUDY

The first case study was based on the architectural design of low income residences, constructed by COHAB-CT – the Curitiba Housing Development Company - within the grounds of the Sambaqui Housing Development. These houses have a total area of 33 m2 distributed in the following rooms: double and single room; living room; restroom and kitchen, as showed in figure 01.
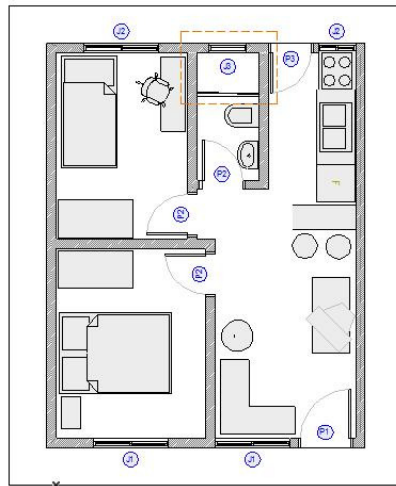
Figure 01: floor plan view of low income residence – COHAB-CT

The collaborative design team was organized according the roles available in the ArchiCAD software. Thus, as it was not a complex design, it was only used the team leader role who was responsible for the design management and the teammate role who was responsible for the design development. After the design set up, it was shared and then the teammates signed-in to it. During the sign-in, the teammates chose their reserved areas, which was first determinate by the team leader. The collaborative tools of ArchiCAD do not support the virtual designation

of the reserved elements, in a way that is necessary to previously do it through other communication media.

Therefore, for this first case study, the architectural design was divided in the following way: one teammate was in charged by the furniture and the ground while the other one was in charged by the slab, walls and the roof. As each stage was concluded, the teammates sent theirs updates to the project and the team leader verified the design development according with the proposed design. The task management was done by the "Mark-up tool", which allowed the communication between designers and the coordination of assigned tasks. The status of the Mark-up style was re-configured as in revision; to review; wait approval and approved. Thus, each time a teammate received an assigned task, it was necessary to give a feedback of the task status to the team leader through "sending and receiving changes". Once a task is completed, the team leader verified it and then deleted this entry, after send a feedback about the task approval for the teammate who was in charge for it. During the collaborative design using the "Mark-up tool" to support the design management many times the teammates forgot to put the nomination for the assigned tasks, which caused a lot of conflicts in the design management. It is an important issue to take care, but this feature in the Mark-up tool is not so evident to the user. Another problem identified was the lack of advice about new messages or new assigned tasks. Therefore, the teammate had to systematically check the system about new entries. The "Mark-up tool" interface can be viewed in the figure 02.
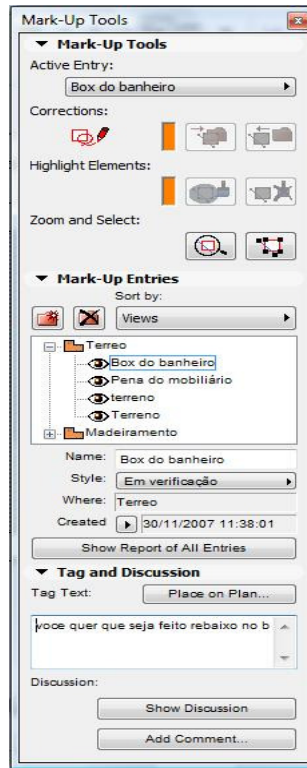
Figure 02: Mark-up tool interface

6. SECOND CASE STUDY

The second case study was based on the architectural design of a house for a particular client in the Blumenau city. The house design has total area of 350 m2 distributed on two floors. The first composed of garage, living room, kitchen, service, home theater. The second floor consists of suites, bathrooms and living as figure 03.
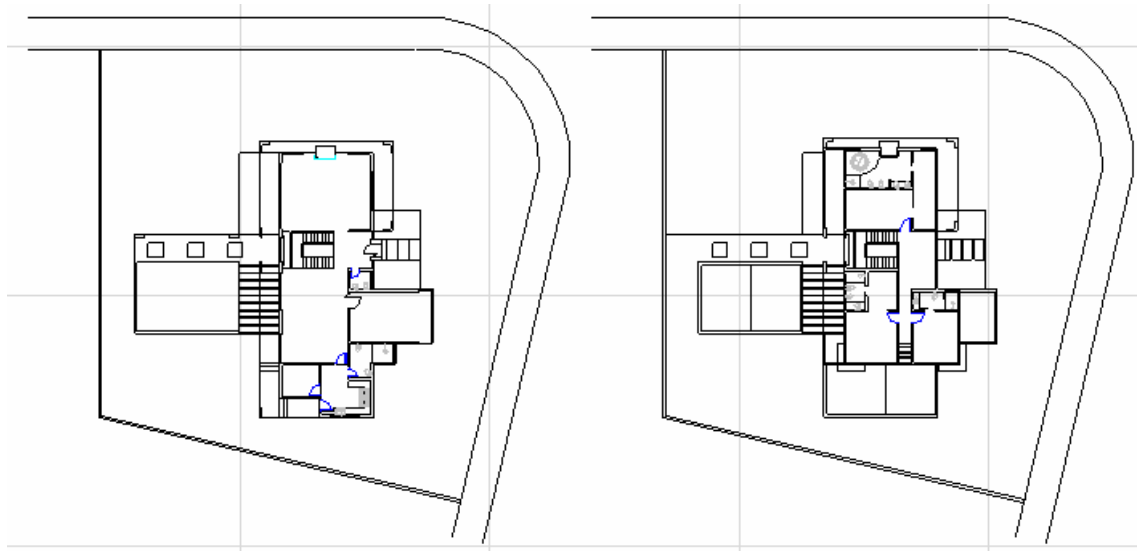
Figure 03: Floor plan view

The team was determined, and it was defined who would be the team leader and team mates this project. It followed the communication plan already described in the research method section. The activity division was carried out by the team members. One of the team mates stayed with the bottom floor and other teammates with the top floor and coverage. All involved in the project received the same configuration to develop the design. The setup was made by the team leader following some settings - ArquiCAD Project Preferences: Dimensions, Calculation Units, Construction Elements, Zones, Layouts, Miscellaneous, Scale, Layers.

During the development of the design, the team leader noted the conformities of the proposed design with what was being developed by teammates but also compatibilization of the entire design. In this study, sometimes the team leader realized that the message sent through mark up were sent without the appointment that was intended. This fact, generate some conflicts between activities. Another error was in relation to sign in the design, where teammates began working on the design without the sign in done by the team leader. The team leader must warn first of the design is open and has been done in sign. If he does it not, the teammates can open the design before the team leader makes the changes necessary to continue the design. Another error was on exchange floors. The team leader forgot to replace the floor for sending the message to the responsible by pavement and warns not mark up. So the message was sent to the teammates, but

the same can not disable any option because he was not with the responsibility of the floor.

It is important to note that in this house design development study it was great easy to view all activities being developed through the two floors simultaneously. This facilitated the team leader to monitor the design and conduct an accounting of how the each drawing continues to be developed through checks.

7. ANALYSIS AND CONCLUSION

Like with any other technology the deployment of ArchiCAD as a tool in the design development at the design offices should occur gradually. In that way it is possible to take many benefits that this tool can bring to them. This tool helps in the whole process of design, forcing companies to be organized structurally in order to create hierarchies between the people who are participating in the design project collaboratively. But if the team is not well trained, and the collaborative principles are not passed, the tool can generate many conflicts of communication and information. Below follows some advantages and drawbacks encountered in using the CAD system during the case studies (chart 02).

Advantages	Drawbacks
- Increased integration among all the teamworkers in the design development	- The messages that are sent through the tool mark up are not notified for whom receives them. The effective communication is not reached.
- Monitoring of the whole design by the coordinator	- When there is lack of element in the mark up, such as the recipient, the tool does not notify this flaw which has just generated some message conflicts.
- Easiness in finding non conformities in the design, since the tool allows a continuous consistency checks during the design development.	
- Easiness of viewing and overlapping automatically the drawings, with team leader coordination assistance.	

Chart 02: Advantages and drawbacks

The guidelines communication used was vital to the initial structure of the entire communication. It improved the clearness and allied to and completed the other collaborative ArchiCAD tools. But it is important to stress that this guidelines should be changed with each new project, which needs upgrading as they arise in the design office. Finally, after the case studies evidences, it was found that the

plan should contain frequency definitions for sending and receiving messages in the mark up, to make it possible to organize the communication.

The main impact brought by a CAD-BIM tool in the collaborative process design refers to the possibility of using a virtual model of construction in order to simulate the shape and behavior of constructive elements. Therefore, from this database, the collaborative design process becomes more integrated and efficient, thus less prone to errors.

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