

Trends in Graduate Research on IT & Architecture: a Qualitative Comparison of Tendencies in Brazil and abroad

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Applications of information technology (IT) in the architectural profession have greatly increased in the past decades, ranging nowadays from concept design to automated construction. There are countless applications in the architecture practice that go well beyond representation, such as BIM software, generative design systems, and rapid prototyping and fabrication. For this reason, IT has been a frequent graduate research topic. In the present research academic graduate theses that dealt with IT in architecture since 1999 were surveyed and categorized, with the purpose of comparing the topics, applications and methods that are studied in Brazil and abroad. We hope that the differences found will help Brazilian architecture schools to update their IT curriculum, overcoming old prejudices against the use of computers in the creative phases of design.

Keywords: *Information technology; architectural design; design process; design education; computational design; CAD.*

Introduction

Applications of information technology (IT) in the architectural profession have greatly increased in the past decades, ranging nowadays from concept design to automated construction. There are countless applications in the architecture practice that go well beyond representation, such as BIM software, generative design systems, and rapid prototyping and fabrication. For this reason, IT has been a frequent research topic in most graduate programs worldwide.

In Brazil, however, the introduction of IT in architecture happened in a very particular way. Brazilian architects had practically no influence from the Design Methods Movement in the 60's and 70's, which had the development of CAD software among its main objectives. There was very little research in Brazilian universities in the field of expert systems for architectural design, while artificial intelligence techniques were being applied to architecture in other countries in the 70's and 80's. Until the 1990's, a market protection policy called "Política de Reserva

de Mercado” made imported hardware and software unaffordable to most Brazilian architects. Moreover, CAD only became a mandatory subject in the curriculum of Brazilian architecture schools in 1994 (Pupo, 2002). These facts explain why Brazilian architects developed a skeptic view of the role of IT in architecture, seeing CAD software mainly as a representation tool.

In order to confirm this hypothesis, we have surveyed the topics that have been studied in 28 different graduate programs regarding applications of IT in architecture. A comparative analysis of these topics helped understanding the role attributed to CAD in architectural design in Brazil and abroad. With this study we expect to start a discussion about new possible contributions of IT in Brazilian architecture and the way CAD is inserted in the curriculum of our architecture schools.

Survey

The survey took place from July to October 2006 and was exclusively based on databases available on the Internet, and on theses that were published in English or Portuguese (in the case of Brazilian theses). The following online sources were surveyed: Proquest; DSpace (MIT); Cumincad; Dedalus (USP); SCIX; CiteSeer; Diva-portal; BDTD; E-THESES. The following keywords were used as search parameters: CAD, CAAD, Computational Design, Design Process, Architectural Design, Rapid Prototyping and Generative System. M.Sc. theses and Ph.D. dissertations from the following universities were found, respectively from Brazil and abroad, within a time range from 1999 to 2006:

- Brazilian universities:

 1. Universidade Federal de Santa Catarina (UFSC);
 2. Universidade de São Paulo (USP);
 3. Universidade Estadual de Campinas (UNICAMP);
 4. Escola de Engenharia de São Carlos (EESC);
 5. Universidade de Brasília (UNB);
 6. Universidade Federal do Rio (UFRJ);
 7. Universidade Federal do Rio Grande do Sul (UFRGS);

8. Pontifícia Universidade Católica do Rio de Janeiro (PUCRIO).

- Foreign universities:

 1. Massachusetts Institute of Technology (EUA);
 2. The Hong Kong Polytechnic University (China);
 3. Vanderbilt University (EUA);
 4. University of Washington (EUA);
 5. Cornell University (EUA);
 6. University of Delft (Netherlands);
 7. Indiana University (EUA);
 8. University of Missouri (EUA);
 9. The University of Texas at Austin (EUA);
 10. Stanford University (EUA);
 11. University of Idaho (EUA);
 12. Concordia University (Canada);
 13. Carnegie Mellon University (EUA);
 14. The Florida State University (EUA);
 15. Harvard University (EUA);
 16. Capella University (EUA);
 17. Technische Universiteit Eindhoven (Netherlands);
 18. Carleton University (Canada);
 19. University of Manitoba (Canada);
 20. Arizona State University (EUA).

The theses that were available in the databases searched came only from four foreign countries: EUA, Canada, Netherlands, and Hong Kong. Although we know there are CAD research groups in most European countries, for simplicity's sake we considered only those in the study.

The 36 M.Sc. theses and 38 Ph.D. dissertations encountered were recorded in a database along with their abstracts. Among the 74 theses, 26 were from Brazilian and 48 from foreign universities. The difference regarding the number of Brazilian and foreign theses can be explained by the fact that most Brazilian universities still do not have their theses available online.

The comparison between the Brazilian and foreign theses aimed at identifying the main differences between them concerning the application of IT in architectural design. It is important to note that the objective of the survey was not statistical, but rather

qualitative. For these reasons, the grounded theory methodology was used in the analysis of the data gathered.

Methodology

The methodology used in the analysis of the surveyed material was a qualitative method known as Grounded Theory. According to Nunan (1992), qualitative research emphasizes “process and meanings”, not necessarily measuring them “in terms of quantity, amount, intensity, or frequency”, while quantitative studies “emphasize the measurement and analysis of causal relationships between variables, not processes.” While quantitative research is based on statistics and quantification, qualitative analysis “can be used to uncover and understand what lies behind any phenomenon about which little is yet known” (Strauss and Corbin, 1998). Such was the

case in the present survey, in which it would have been impossible to have access to all the theses on IT and architecture published throughout the world in recent years.

Grounded Theory was originally developed by Barney Glaser e Anselm Strauss in the 60’s, and was highly influenced by Dewey’s theories. It was defined by Strauss and Corbin (1998) as a study in which results are “discovered, developed and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon”. In this kind of study, “one does not begin with a theory, then prove it”, but rather “one begins with an area of study and what is relevant to that area is allowed to emerge” (p. 23). This means that the researcher might come close to the subject to be investigated without a theory to be tested, but willing to understand a particular situation or a certain phenomenon, through several collection methods.

Table 1
Topics present in the
Brazilian theses

Theses analysis																						
Brazilian theses published from 1999 to 2006																						
Theses	Year	Master / Doctorate	Implementation of CAD technology in Brazil	CAD software analysis	CAD support in design process	Legal design phases	Interaction CAD / User	Architectural Composition	3D Models/ Topology	Indoor environmental quality	The early phases	Design teaching and history	CAD for Design	CAD for Drawing	CAD lab layout	CAD in the Web / Collaborative Design	TRIZ (Theory of solving inventive problems)	Design Process	Design firms management	Programming / Algorithms / Math Models	Implementation	
1	1999	M																				
2	1999	M																				
3	1999	M																				
4	2001	M																				
5	2001	M																				
6	2002	M																				
7	2002	M																				
8	2003	M																				
9	2003	M																				
10	2003	M																				
11	2004	M																				
12	2004	D																				
13	2004	M																				
14	2004	M																				
15	2004	M																				
16	2004	M																				
17	2004	M																				
18	2004	M																				
19	2005	M																				
20	2005	M																				
21	2005	D																				
22	2005	D																				
23	2006	M																				
24	2006	M																				
25	2006	D																				
26	2006	M																				

Afterwards, with all the collected information, the researcher compares and encodes them. With this information it is possible to extract the regularities and at this point, the researcher is able to describe

the theories resulted from a rigorous analysis. The present research started with the hypotheses that there were differences between the topics being studied in Brazil and abroad in the area of IT and

Theses analysis

Abroad theses published from 1999 to 2006

Theses	Year	Master / Doctorate	Interaction CAD & Design Process	Quality X. Quantity in CAD	Traditional Tools x CAD Tools	Geometry / Topology	Interaction CAD / User	CAD & Drafting	Design Process	Shape Grammar	Design teaching with CAD	CAAD in the Web / Collaborative Design	Decision Making / The early phases	Visualization & Form exploration (2D-3D)	CAM and RP	Virtual Reality	Programming / Algorithms / Param Models	Implementation
1	1999	D																
2	1999	M																
3	2000	D																
4	2001	M																
5	2001	M																
6	2001	D																
7	2001	D																
8	2001	D																
9	2002	D																
10	2002	D																
11	2002	D																
12	2002	M																
13	2003	D																
14	2004	M																
15	2004	M																
16	2004	D																
17	2004	M																
18	2004	M																
19	2004	M																
20	2004	D																
21	2004	M																
22	2004	D																
23	2004	D																
24	2004	D																
25	2004	M																
26	2004	D																
27	2004	D																
28	2004	D																
29	2004	D																
30	2004	D																
31	2004	D																
32	2005	D																
33	2005	D																
34	2005	D																
35	2005	D																
36	2005	D																
37	2005	D																
38	2005	D																
39	2005	D																
40	2005	D																
41	2005	D																
42	2005	D																
43	2005	D																
44	2005	M																
45	2005	D																
46	2005	M																
47	2005	M																
48	2006	D																

Table 2
Topics present in the foreign theses

architecture. However, we did not know what type of differences were those. The data analysis was done in three-steps: (1) firstly the most important topics that each thesis dealt with were listed; (2) each thesis was associated with the corresponding topics from the list; (3) finally, the theses were grouped in broad categories based on the topics discussed by them. The analysis of these broad categories allowed conclusions to emerge.

Table 3
Group 1 (Brazilian theses)

Theses analysis

The data collected was organized in two tables (Brazilian and foreign theses). After a preliminary analysis of the contents of each thesis the following topics were identified in each group (22 topics for the Brazilian theses and 25 topics for the foreign theses):

- Group 1 (Brazilian theses): implementation of CAD technology in Brazil; CAD software analysis; CAD support in design process; preparation of legal documents with CAD; CAD user interface; architectural composition; 3D modeling; topology; early phases of design; design education; environmental quality; CAD for design; CAD for Drawing; CAD lab layout; collaborative design; CAAD in the Web; TRIZ (Theory of solving inventive problems); design process; design firm management; programming; algorithms; CAD implementations.
- Group 2 (foreign theses): interaction between CAD and the design process; quality X quantity in CAD; traditional tools x CAD tools; geometry; topology; positive/negative aspects of CAD in the design process; solving the negative aspects of CAD in the design process; shape grammars; mathematical models; algorithms; 3D parametric models; programming; design process evaluation; teaching with digital tools; web-based CAAD; collaborative design; decision-making support; the early phases of design; form exploration (2D-3D); visualization; CAM-computer-aided manufacturing; rapid prototyping; virtual reality; CAD implementation.

Two tables were produced showing the topics that were present in each thesis (tables 1 and 2).

Looking at tables 1 and 2, it was possible to group the theses that had topics in common, and to put them under new, broader categories, as shown in tables 3 and 4.

Looking at these broader categories, it was possible to understand the differences between the

Category	No. of theses
Evaluation of CAD packages	2
CAD in the design process (as an administrative tool, for visualization, and for remote collaboration)	6
CAD for optimization, analysis and simulation	2
CAD in education (in architectural design and graphic expression)	8
CAD for developing topological and complex forms	2
CAD and computational concepts in the initial phases of design	3
Computational concepts (Palladio; object-oriented design and shape grammars)	3

topics being studied in Brazil and abroad. Among the topics researched in Brazil most were somehow related to education and to the role of CAD in the design process. These studies tried to answer the following question “*is it necessary to introduce IT in the design process?*” In other words, it seemed as if it was still necessary to prove that CAD needs to be present in the architectural curriculum and in the design practice.

This type of worry was not so common in the second group. In the foreign theses, topics such as parametric design, shape grammars, generative systems and other computational concepts were very common, along with digital design fabrication and rapid prototyping techniques. These studies were answering the following question: “*how can IT be introduced into the design process?*” This shows

Table 4
Group 2 (foreign theses)

Category	No. of theses
Parametric design	4
CAD applications for the design process	9
Design education	3
Programming in design education	3
Computation in design	5
Computational concepts	5
Programming in architectural design	1
CAD for analysis	2
Digital fabrication	3
Remote/distributed collaboration/education	3
Computational design critique/theory	2
Knowledge-based systems and decision support	4
Visualization/representation	4

how the foreign theses were a step beyond the Brazilian studies.

There was no reference to rapid prototyping or even computer-aided manufacturing – CAM – in any of the Brazilian theses surveyed. In fact, in Brazil there are only two architecture schools where this technology is available, while most of the foreign universities where the theses surveyed were developed already have rapid prototyping laboratories.

Besides, none of the Brazilian theses touched topics such as “expert systems” or “decision-support systems”, which confirms the hypothesis that AI concepts are not an important influence in Brazilian architecture research.

The most interesting finding, however, was the fact that in the foreign group many researchers developed implementations of CAD tools, while in Brazil only two of the theses surveyed included implementations. It can be inferred that Brazilian architects are not so interested in developing their own tools, which makes them more dependant on imported CAD packages. Foreign researchers on the

other hand, seem to be willing to take a more active role in the definition of their computational design tools. More than that, they seem to be willing to use programming and scripting as a strategy to become less dependant on the commercial packages limitations.

Discussion

It is important to notice that, in order to overcome the gap in the way Brazilian architects use IT in architecture, importing foreign models will not suffice. The availability of new technologies can lead to applications that are not guided by necessity, but rather by excessive enthusiasm. This has been the case in many countries in which free-form constructions that defy constructibility – and sometimes good-taste – have been produced as a proof of technical development.

The fact that we were not exposed to the developments of IT in the 60’s, 70’s and 80’s made Brazilian architects different from North-American and European architects. Besides, our construction traditions and workmanship is very different from the construction traditions in those countries as well. For these reasons, we should spend more time developing our own computational theories of design.

We hope that the findings of the present research will contribute to establish a new agenda for CAD education in Brazilian architecture schools, as well as new trends in graduate research, and help overcoming old prejudices against the use of computers in the creative phases of design.

Acknowledgements

The authors would like to thank FAPESP – São Paulo state’s research funding agency – for funding this research.

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