Notes on Digital Architectural Design in the Undergraduate Teaching in Brazil

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This study focus in design process that uses the digital environment in context of undergraduate courses of Architecture and Urbanism, mainly the Digital Architectural Design (DAD). From author's previous studies that classified the teaching practice in Latin America, the Brazilian data were analyzed due to its expressive and heterogeneous features. Faced with a scenario that points to institutional characteristics reflect in the teaching approach, a horizontal mapping was performed. A data cross-referencing through correlation methodology was carried out. As result, there is a prevalence of public institutions that use teaching practice using DAD, most of them located at South and Southeast with a close link between teaching and research.

Keywords: *Digital Architectural Design, Levels of design computability, Mapping study, Teaching practices*

INTRODUCTION

This paper presents partial results of an ongoing PhD research, whose the main goal of this study is to map educational practices developed in undergraduate courses of Architecture and Urbanism in Brazil that explore the design process in the digital environment. In this way, this paper was planned to construct a layer of information that gives a base to discuss this subject.

Oxman (2008) refers to the acronym DAD - Digital Architectural Design - to describe the use of design methodologies fully supported by digital environment and exclude from this concept digital tools that only replicate analogical methods.

Faced the emergence of the DAD, it is understood that research on methods, tools and practices that have been developed in academic environment become extremely relevant. As Kalay says: *"Schools of*

architecture, therefore, have the responsibilities of understanding these changes, and guiding them, while educating new generations of architects who will use these methods, tools, and practices to change the environment in which we live." (KALAY, 2009, pag. 6).

Researches about DAD concept are already established at least a decade ago. For at least a decade, tools that explore a language based on visual programming are being diffused in Latin America (HERRERA, 2011). On the other hand, Flório (2012) affirmed that Informatics have an operational and instrumental focus in Brazilian undergraduate courses. Following this trend, Celani et. al, (2017) evaluated the same context and observed that experiments using new technologies, including programming languages, are scare in the country and are still isolated experiences which focus in the software use. But studies with qualitative and quantitative information

about the recent scenario are not yet available.

This study intends to fill this gap by mapping some topics of the current state of architecture teaching in Brazil, by means of crossing data about the use of new digital design technologies with qualitative and quantitative features of undergraduate courses.

In order to analyze recent developments in the region, the present study takes up previous studies conducted by systematic review (VASCONSELOS, SPERLING, 2016;2017). The aim of these studies was to mapping the state-of-art of DAD in undergraduate Architecture and Urbanism studies, from 2006 to 2015, in the Latin America context. This systematization was based on different modes of interaction between Designer and Representation in the design process in digital environment (OXMAN, 2006) and on the levels of computability: representational, parametric, and algorithmic (KOTNIK, 2010). Even if these topics had been focused in later works by these and other authors, the proposed framework by the combination of classifications proposed by Oxman (2006, 2008) and Kotnik (2007, 2010) is still valid.

The parametric and algorithmic levels are associated with an advanced level of computability and established as DAD. The levels of computability are presented in Figure 1.

In the process of *Interaction with digital constructs* (OXMAN,2016) or in the *Level of design computability representational* (KOTNIK, 2010), the designer interacts directly with representation. And, as previously presented in Figure 1, it is basically composed by the class of CAD models. This level of computability is divided in: CAD descriptive model, Generation-evaluation CAD model, CAD descriptive models and their evolution to dual-directional digital process. From these models, designer and computer have a logic interaction similarly to the process developed on paper. In order to describe the similarity, Kotnik applies the expression *"electronic drawing tool"* (2010, pag. 8)

The *Interaction with a digital representation generated by a mechanism* (OXMAN, 2006) or the *Level of design computability parametric* (KOTNIK, 2010), the designer does not interact directly with representation. He interacts by a variable control of parameters that conform a mechanism to generate the model.

The *Interaction with digital environment that generates a digital representation* (OXMAN, 2006) or *Level of design computability algorithmic* (KOTNIK, 2010), the design process is developed from the interaction between designer and computational mechanism. The user identifies and explicitly criteria to guide the generative process. The generative process starts from algebraic, analytical and geometric operations that emerge an architectural object.

Therefore, from the previous systematic reviews and using data visualization (LIMA, 2011), it is proposed to analyze the specific scenario of the DAD in Brazil - the Latin American country with greater number and diversity of experience in the field (VASCONSELOS, SPERLING, 2016;2017).

METHODS

While the Brazilian system of universities is composed by public institutions, big private companies of education and small private institutions, the research system is almost all in public universities. Recent studies show that 90% of the Brazilian research is produced by the public sector (universities and research centers). Thus, our hypothesis is that mapping this scenario is relevant to understand what is going on in the specific context of DAD in architecture undergraduate courses in Brazil, drawing on some correlations. As Abrams and Hall says *"mapping has emerged in the information age as a means to make the complex accessible, the hidden visible, the unmappable mappable"* (ABRAMS, HALL, 2006: 12).

This research is based on a descriptive study (GIL, 2010) by means of a series of correlational analysis (GROAT & WANG, 2013). The correlational research is focused on patterns of relationships between two or more variables presented in the specific context. In our case, the data from the undergraduate courses were compared with the didactic practices according to the levels of computability mapped in previous studies (VASCONSELOS, SPERLING, 2016 ;2017).

Figure 1
Levels of Design
Computability,
categories and
subcategories.
Source: authors
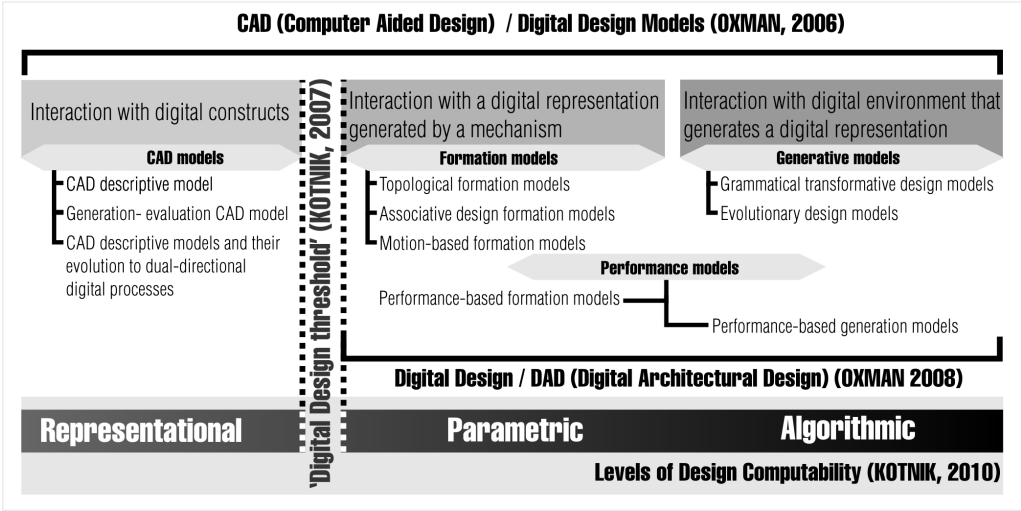adapted from
Oxman (2006,2008)
and Kotnik
(2007,2010).

CAD (Computer Aided Design) / Digital Design Models (OXMAN, 2006)

Interaction with digital constructs

CAD models
- CAD descriptive model
- Generation- evaluation CAD model
- CAD descriptive models and their evolution to dual-directional digital processes

'Digital Design threshold' (KOTNIK, 2007)

Interaction with a digital representation generated by a mechanism

Formation models
- Topological formation models
- Associative design formation models
- Motion-based formation models

Interaction with digital environment that generates a digital representation

Generative models
- Grammatical transformative design models
- Evolutionary design models

Performance models
Performance-based formation models —
Performance-based generation models

Digital Design / DAD (Digital Architectural Design) (OXMAN 2008)

Representational **Parametric** **Algorithmic**

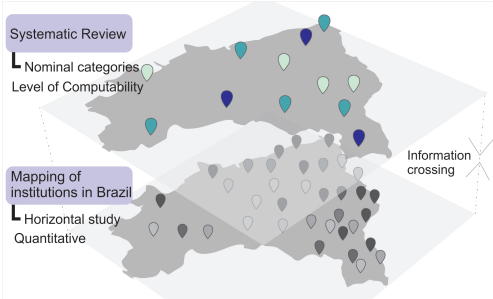**Levels of Design Computability (KOTNIK, 2010)**

Figure 2
Methodological
scheme of the
study.

The previous study was a systematic review that sought the CumInCAD database, until April 2017, and analyzes 13053 articles. The applied search strategy the following terms were used: educa (for education, educate...), teach (for teaching, teacher...), learn (for learning, leared...) e dida (for didatic). To be included in the review, the articles should obey the selection criteria: 1) studies performed between 2006 and 2015; 2) performed in Latin America; 3) carried out in Undergraduate level; 4) that explored the creative process in digital environment.

It is important to highlight that the accounting of the teaching practices was related to the year of publication and not to the year of its accomplishment, given the fact that not all the articles explain this data. However, even considering this bias, this systematic review contains the first mapping of DAD teaching practices in Latin America. It is also worth noting the importance of mapping and data collection that analyzes teaching practices carried out over a decade, using a research methodology based on a correlational study, which is validated by Groat and Wang (2013).

Our study focus on the Brazilian teaching practices, which correspond to 48% of the sample from

the previous study. Figure 2 shows the methodological scheme of the study, the correlation between the systematic review with the mapping of institutions in Brazil.

Systematic Review
∟ Nominal categories
Level of Computability

Mapping of
institutions in Brazil
∟ Horizontal study
Quantitative

Information
crossing

DEVELOPMENT
Information mapping as a strategy for immersion on the context of Architecture and Urbanism teaching in Brazil
An information mapping of all the Architecture Schools in Brazil was performed The search was carried out from October 2017 to February 2018 on

the database of the Brazilian Ministry of Education and Culture (MEC). Data were extracted manually and compiled in a specific table for the study (Microsoft Excel 2017, United States). The following variables were collected: Course score according to government agencies and national examinations; Number of authorized places; Modality and situation (classroom or distance learning; open, in process, closed); Course implementation (date); Administrative nature of the institution (private or public); City and state.

Initially, 690 undergraduate Architecture courses were identified, of which 18 distance-learning courses were removed. The final sample had 672 undergraduate courses, 591 are already implemented and working. This data was systematized and was presented in Figure 3, organized by important criteria related to the context, explained separately below.

From the data systematization, it is possible to observe the temporal period and location by regions about the implantation of Architecture and Urbanism In-Class courses in activity in Brazil (Figure 3, top part). Two periods of greater expressiveness related to the growth rate of courses are identified. The first occurred in the 1970s and the second in the present decade, with a growth rate of 192% and 174%, respectively. It is important to highlight that the last decade is not complete, since its analysis was performed in 2018.

In the bottom part of Figure 3, is observed the proportion between public and private institutions (left part), and the relation between institutions localized in Capitals and other cities (right part). This mapping was performed in three scales (national, regional, and states) to explain those differences.

The relation between public and private institutions demonstrate a higher number private institutions in most of states. However, this difference is not highlighted in the regional and national scales. There is a higher amount of private institutions in South and Southeast regions, and this relation also occurs in Midwest and Northeast regions. Only one state showed 100% of public institutions, whereas the number of private institutions ranged from 65%

to 100% in the other states.

About the analysis of institutions located in Capitals or other cities, there is a significant difference between North and South regions. It is visualized a continuous, almost predominantly green spot in the South to Southeast regions. Also, the Midwest regions showed a heterogeneous relation between the states, the institutions localized in Capitals varied from 33% to 100%.

Teaching practices in terms of computability levels

During the classification process of experiments, it was verified that some of them could be classified between classes extracted from Oxman (2006) and Kotnik (2010) as it was observed the coexistence and transition between the levels of computability in a same didactic practice. Consequently, the initial classification was expanded and two intermediary classification were created (representational and parametric; parametric and algorithmic). Figure 4 shows the classification of the Brazilian didactic experiments between 2006 and 2015 according to levels of computability.

From the data of the analyzed period (2006-2015), the level of computability of 42.6% of teaching practices were classified as representational, 29.6% as representational combined to parametric, 20.4% as parametric, 5.6% as parametric combined to algorithmic, and only 1.9% as algorithmic. In Figure 4, from the total quantitative of the scenario (Pie chart) one has the idea of the expressiveness of the experiments based on the level of computability representational. The systematization developed for this paper explore the criterion of temporal periods, there is a layer of information giving evidence of a process of awareness of the potentialities of the more advanced levels of computability over the last 10 years (Graph in Bars of Figure 4).

Figure 3
Scenario
explanation
through
infographics. In the
top: Regional
distribution of the
institutions with
date of
implementation.
On the bottom left
corner: the
proportion
between private
and public
institutions. On the
bottom right
corner: the
institution locations
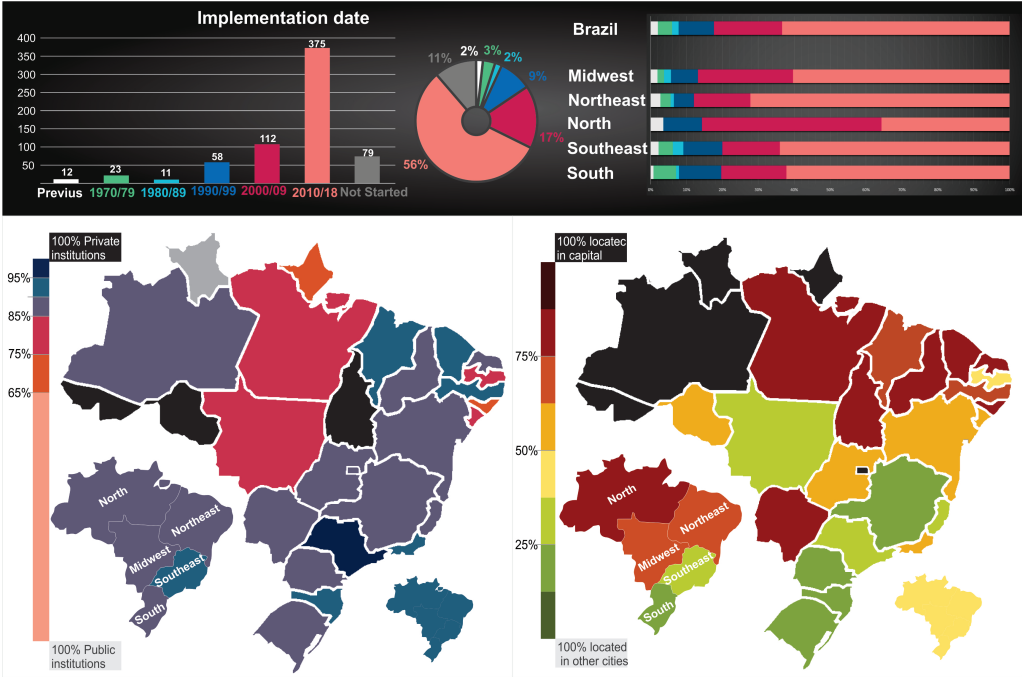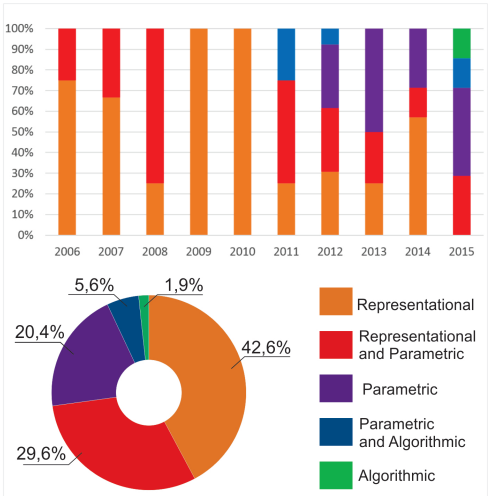proportion
between State's
capital and other
cities.

Figure 4
Graphs about
teaching practices
from the
systematization of
computability
levels, general and
temporal data.

Also, it was decided to exclude from the sample the experiments referring to interactions with representational computability level. Therefore, the focus was the understanding of the scenario of teaching practices that explore at least mixed strategies being one of them DAD (Figure 06). The total data (pie chart) show more than half of the DAD experiments are associated with representational processes. However, a transition scenario is identified, in which the incorporation of the DAD into teaching over the years.
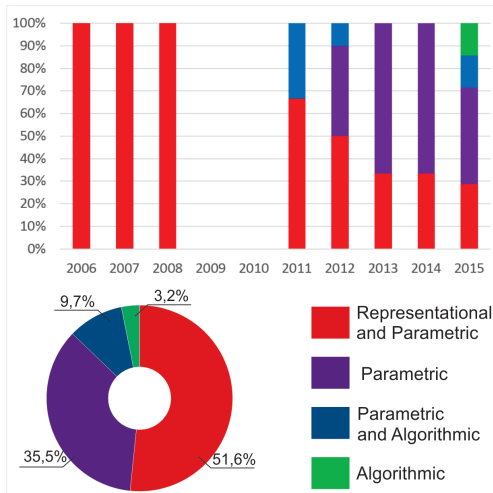
The data information systematized in Figures 4 and 5 were mapped in the territory, placing the teaching strategies according to cities where they were developed. Figure 6a presents all didactic practices in digital environment in Brazil. Figure 6b considers only the experiments in DAD, and excludes didactic practices based on representational level. This graphic shows the localization of the cities and, consequently, more dynamic regions in the production of articles about didactic practices. In the two mappings, it is observed the prevalence of practices in the South and Southeast regions, with some experiments in the Northeast and Midwest.

Considering only experiments in DAD - therefore, excluding teaching practices based in level of computability representational - the more dynamic cities were Campinas and São Paulo with five experiments. Belo Horizonte, Chapecó, Florianópolis, Pelotas and São Carlos showed three to four experiments. Cities that stand out in the scenario with all interactions as Pelotas and São Carlos are observed, however, at the moment that the DAD interactions are analyzed these do not stand out.

Also, in the mapping presented in Figure 6b it was possible to identify cooperation networks for studies carried out in more than one institution. Four papers had didactic experiences that involved a network of institutions in the country and three experiments with international collaboration.

RESULTS AND DISCUSSION

By crossing the institution's mapping with data from previous systematic review, we were able to extract a more realistic view of the situation. The use of computer is widely diffused in Brazil for representation in Architectural Design, and there are a significant number of teachers (some of them researches) dedicated to the subject. However, the didactic experiences developed and reported in undergraduate courses with advanced levels of computability are not representative when compared with the macrostructure of the Brazilian Architecture and Urbanism teaching.

It is observed that most of the research is performed in public universities (70.0%), compared to private universities (30.0%). However, it is important to highlight that there is a different proportion between the number of public and private universities. In Brazil, there is only 57 public institutions compared to 534 privates. Therefore, despite the smaller number of public universities, most of the academic production is originate from these institutions.

Regarding the location of the institution and development of DAD practices, again we find a discrepancy. Analyzing the scenario, 47% of the DAD practices were developed in capital cities, and 53% in inner ones. However, only 39.8% of the institutions are localized in the capital cities. It demonstrates that the universities of the capital cities are implementing a greater number of DAD practices when compared to universities of inner cities. Also, most of courses that presented DAD practices are located in Southeast and South of Brazil (Figure 06).

Figure 5
Graphs about teaching practices and computability levels in Brazil (2006-2015) after the exclusion of the representational level
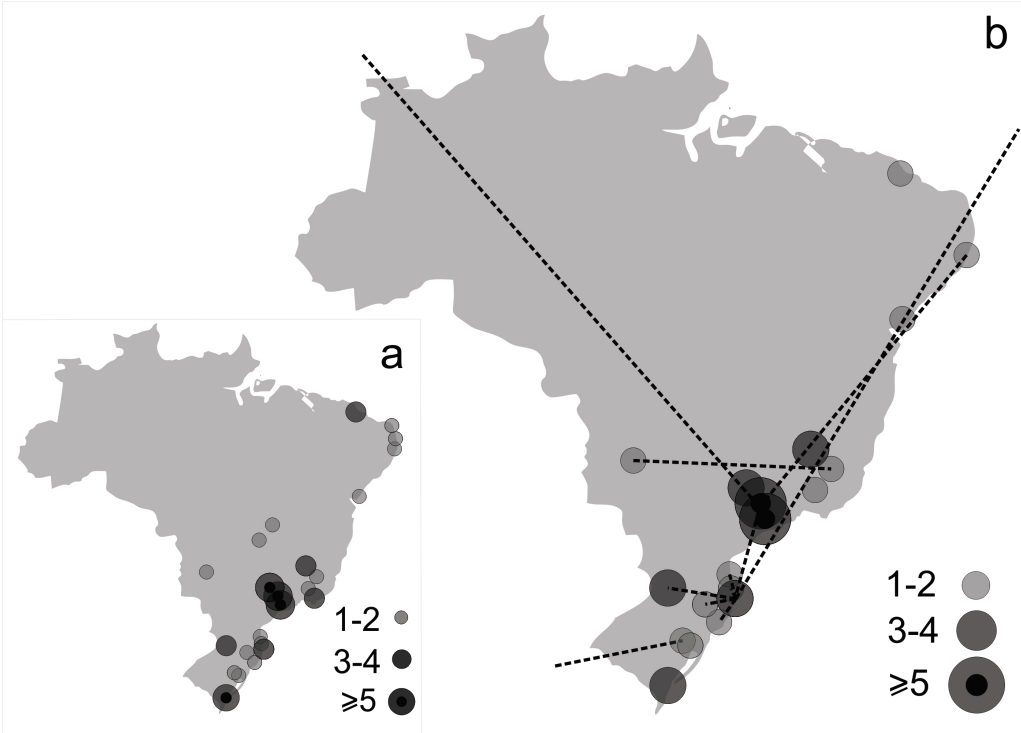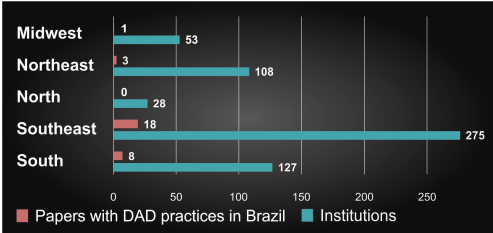
Moreover, 66.6% of the institution that reported DAD practices were those implemented before the 1980's. Also, it is noted that all the cases with DAD practices where performed in institutions implemented in the last century. On the other hand, from MEC data, 82% of Architecture courses were implemented after 2000.

FINAL CONSIDERATIONS

The relevance of this data crossing to the formal and spatial recognition of the current scenario. Faced to 54 teaching practices from only 27 institutions of a scenario of 591 courses. Also, it was analyzed 30 teaching practices that minimally explore some development in DAD, in 20 institutions.

The study shows how the insertion of DAD in Brazil depends on factors linked to education and research policies. In general terms, public institutions - and sometimes private ones - invest in the initiative between teaching and research in DAD. Most of courses linked to private institutions have targeted the current market suggests with small investment in innovation.

Faced with this scenario that need advanced, we

are developing qualitative studies focused in each one of the cases of use of DAD in Brazil, identifying potentialities and limits, in the sense to increase the application of DAD in Brazil.

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