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ARTIGO

DECODING AND RECODING INFORMAL SETTLEMENTS IN A DESIGN STUDIO: AN OVERVIEW OF THE WORLD STUDIO PROJECT

DECODIFICANDO E RECODIFICANDO ASSENTAMENTOS INFORMAIS EM UMA DISCIPLINA DE PROJETO: UMA VISÃO GERAL DO PROJETO WORLD STUDIO

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ABSTRACT:

The world experiences a surge in population accompanied by fast urbanization processes. As a result, cities face numerous urban and social problems, leading to the emergence of informal settlements. In response, computational and parametric resources are being adopted to support innovative approaches to urban planning and design. This paper describes the World Studio, a teaching experience that unfolds since 2017, in which undergraduate architecture and landscape architecture students learn how to use shape grammars and parametric tools to design for informal settlements in international contexts (Brazil and India).

KEYWORDS: shape grammar; parametrization; urban design; teaching experience.

RESUMO:

O mundo assiste a um rápido aumento de população acompanhado por processos de urbanização acelerada. Em resultado, as cidades enfrentam inúmeros problemas urbanos e sociais, levando ao aparecimento de assentamentos informais. Em resposta, recursos computacionais e paramétricos têm sido adotados para apoiar novas abordagens ao planejamento e desenho urbano. Este artigo descreve a experiência de ensino do World Studio que decorre desde 2017, no contexto da qual estudantes de arquitetura e paisagismo aprendem a usar gramáticas da forma e ferramentas paramétricas para intervir em assentamentos informais em contextos internacionais (Brasil e Índia).

PALAVRAS-CHAVE: *gramáticas da forma; parametrização; desenho urbano; experiência de ensino.*

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INTRODUCTION

The proportion of the urban population living in informal settlements rose from 23% in 2014 to 24% in 2018, reversing the trend of the previous 4-year period. Over 1 billion people are living in inadequate housing conditions, and if the trend continues, 3 billion people will be living in the same conditions by 2030 (UNITED NATIONS, 2020). While fast urban growth outpaces infrastructure development, informal settlements increase in terms of size and population (UNITED NATIONS, 2020). In response, computational and parametric resources have increasingly been adopted to develop novel approaches to urban planning and design. These resources can identify and reinterpret built patterns in informal settlements and improve urban quality without losing their essential features, such as spatial diversity and cultural adequacy (VERNIZ, 2020).

This paper aims to discuss the use of computational approaches to intervene in informal settlements within the context of a teaching experiment called World Studio. To this end, we present and discuss the results and the students' perceptions of the experiment. Results show that: i) the students believed that the studio had improved their computational skills - although a few recognized some difficulty in assimilating software content; ii) the students stated that the course had improved their abilities to understand and develop their design ideas; iii) the students were able to implement dynamic and flexible proposals that are sensitive to the cultural and social aspects they perceived during the site visit, and; iv) the studio contributed to increasing students' capacities for dealing with urban design as a whole (and more specifically with informal settlements).

BACKGROUND

LACK OF HOUSING/INFORMAL SETTLEMENTS

First identified in mid-nineteenth-century France, America, and India, informal settlements tend to emerge in response to fast urbanization processes (DAVIS, 2006). In the present day, informal settlements can be seen all around the world. Overall, these settlements are diverse in nature, with specific features rooted in their local cultural contexts, making it difficult to characterize them.

Informal settlements, although often considered inadequate, constitute a relatively affordable housing solution as a result of not following building or planning codes and by being located in areas of the city that are deemed unsuitable for the formal housing sector, usually occupying the land illegally (COMPANS, 2007; MARICATO, 2001). Informal settlements often lack urban infrastructure such as sanitation, public amenities, green areas, and public open spaces. They also tend to present organic and spontaneous patterns, whose complexity may be desirable but challenging to survey, making it difficult to plan interventions to upgrade and integrate these areas (VERNIZ, 2020). In this context, digital technology can be a helpful tool for collecting and managing data and for devising appropriate planning strategies.

COMPUTATIONAL APPROACHES TO URBAN SETTLEMENTS

The work developed in World Studio is partially rooted in shape grammar theory. Shape grammar is an algorithmic process to generate a design. Beginning with an initial shape, this algorithmic process relies on identifying and using visual rules to transform one shape into another through iterative means until a design considered to be final is achieved (STINY & GIPS, 1972). Additional visual and symbolic aids such as labels, colors, and verbal

descriptions, can be added to support and constrain the derivation process and obtain new designs (STINY, 2006). The shape grammar methodology is well-suited to deal with recursive tasks, avoiding the excessive use of repetitive solutions that characterize massified approaches to design.

Shape grammars can be used for both analytical and generative tasks. For analytical tasks, the focus is codifying the patterns and recognizing the formal structures of an existing set of designs. The shape grammar method can also be used to upgrade existing designs (ELOY & DUARTE, 2011) and develop new shape grammars in a meta-generative process (KNIGHT, 1989; 2014).

Teeling (1996) proposed the first urban grammar to describe the urban form in the docklands of Friedrischafen, Germany. Duarte et al. (2007) presented an urban grammar for the Marrakesh Medina, Morocco, an ancient urban fabric that developed into its present-day complex urban form through spontaneous growth over time. Duarte and Beirão (2011) proposed shape grammars to support flexible urban planning—an idea advanced in their subsequent City Induction project, which developed an integrated tool to formulate, generate, and evaluate urban plans (DUARTE et al., 2012). Their proposed methodology uses pattern languages to identify urban patterns, shape grammars to encode these patterns, and parametric design to implement them, and it can be used to analyze existing contexts and develop new solutions.

In recent years, urban grammars have attracted significant research interest focused on their potential for informal settlements. For instance, Barros et al. (2013) presented a grammar to describe a Mozambican slum called Cidade dos Caniços. Verniz and Duarte (2020) proposed a grammar for the Santa Marta favela in Rio, Brazil, which encodes the rules underlying the spontaneous growth of informal settlements in the city's steep terrain and explains how the built environment is shaped as a result of the immediate urban context and the area's distinctive topography. That grammar was later transformed following the methodology proposed by Eloy and Duarte (2011) and Knight (1989; 2014) to support the design of new environments with selected features similar to the existing environment but with refinements and interventions needed to improve the quality of life (VERNIZ, 2020; VERNIZ & DUARTE, 2020).

METHODOLOGY AND THEORETICAL FRAMEWORK

World Studio is based on the work of Duarte and Beirão (2011), who argued that the dynamics of contemporary urban societies demand a flexible urban approach. We drew on the computational and parametric methodology they developed and adapted it to suit our purpose of reconfiguring and formalizing informal settlements in urban contexts. Offered every spring semester since 2017 at the Pennsylvania State University, the World Studio is offered to undergraduate architecture and landscape architecture students who learn how to encode, decode, and recode built patterns to improve urban quality while preserving the spatial features that make informal settlements recognizable as a distinct urban environment.

World Studio aims to provide students with opportunities to develop a strong understanding of how political, social, and environmental constraints influence how contemporary cities are shaped and to draw on this knowledge to create flexible plans that include affordable housing and address other quality of life issues in informal settlement environments. World Studio is part of ongoing research that uses new technologies to understand the structure of informal settlements and to develop new approaches to urban design.

We use the related concepts of grammatical transformation (KNIGHT, 1989; KNIGHT, 2014) and transformation grammar (ELOY & DUARTE, 2011) as the basis for the design

methodology used by the students in World Studio. Grammatical transformations occur at the rule level of a shape grammar (meta-transformation) by transforming, subtracting, and adding rules, thereby generating new shape grammars (KNIGHT, 1989). Transformation grammars are shape grammars designed to change an existing design and generate a final design that constitutes a changed form of the initial one (ELOY & DUARTE, 2011). Figure 1 shows how transformation grammars and grammatical transformations relate to the first cycle of three World Studio interventions in Rio.

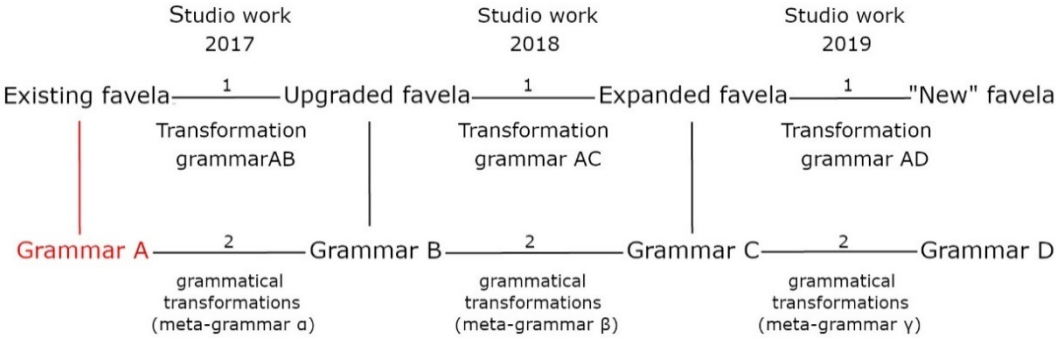

Figure 1. Diagram showing the relation between the studio iterations, shape grammars, transformation grammars, and grammatical transformations.

Source: the authors.

The City Induction methodology (DUARTE & BEIRÃO, 2011) was used to identify and understand existing built patterns. This methodology is used to develop a set of solutions (using shape grammars) from which the designer can select one or more designs to refine further for eventual implementation.

The studio is organized into six main phases. During Phase 1, briefing, the students are introduced to the intervention area and the basic principles of practices central to using pattern languages, shape grammars, and visual programming languages (Grasshopper 3D) through a series of intensive workshops. In Phase 2, analysis, the students receive an introduction to the local cultural and socio-political contexts and perform a comprehensive analysis of the intervention site, using patterns and shape grammars to describe local housing types and urban morphology. Phase 3, strategy, focuses on the students using pattern languages to plan the program for their urban interventions. In Phase 4, conceptual urban plan, the students use shape grammars and Grasshopper 3D to codify their planned patterns and develop flexible urban schemes. Phase 5, intermediate urban plan, centers on the students refining the schemes underlying their urban plans. The project ends with Phase 6, detailed urban plan, in which the students develop their proposed plans with an increased level of detail at a smaller scale. They are also requested to present a comprehensive description of the underlying patterns of their proposals and the corresponding shape grammars. In addition, they are asked to list the rules of their grammars, explain how they can be used in the generation of design solutions, give an idea of the space of possible design solutions, and apply their grammars in the design of a specific solution for their site.

At the end of the semester, the students were asked to complete a survey designed to capture their opinions of the computational tools used in the design studio. The survey consisted of 8 questions with answer options provided on a Likert scale from 0 to 5, with 5 being the highest evaluation. The questions related to the students' experience with specific tools, for example, "Did you improve your scripting skills (in Grasshopper) during this studio?" The survey was administered for all four iterations of the World Studio that are described in this paper. However, the results are presented for only the interaction of 2020, given that these results are broadly representative and reflect the most recent studio.

THE WORLD STUDIO PROJECT

The intervention area for the World Studio changes every three years. So far, students have worked with intervention areas in Brazil (2017-2019) and India (2020).

WORLD STUDIO RIO 2017-2019

For the first three years of interaction with an informal settlement, World Studio proposed intervention in Rio de Janeiro, Brazil. Santa Marta favela was the intervention case for the first two years. This settlement was chosen for various reasons: it constituted a paradigmatic example of local informal settlements, presented both urban and topographic complexity, and could be visited safely.

In 2017, the design problem focused on upgrading Santa Marta, and proposals were based on the informal armature strategy (GOUVERNEUR, 2015), which specifies that interventions should be punctual on areas of a settlement with the potential to trigger wider incremental regeneration by strengthening existing positive aspects, and on transformation grammars. The students attended lectures offered by faculty members, researchers, and invited lecturers, covering the following subject areas: geographic information systems (GIS), pattern languages, shape grammars, informal armature strategies, and Brazilian informal settlements.

In 2018 the design problem was to provide guidelines for the growth of the settlement into an annexed area. The students participated in workshops on shape grammars and Grasshopper 3D that were more intensive than in the previous year. Similar to the previous year, the students were provided with several types of upgraded data on the settlement.

In 2019, the World Studio focused on Rio de Janeiro. Students could choose between three areas for intervention. The design problem was to provide guidelines for a new affordable housing settlement based on the patterns of the Santa Marta favela. The students had access to the same type of data as the previous years. To assess whether VR as an effective tool to support remote visits by comparing with the two previous iterations of the World Studio, the students visited Rio de Janeiro in the middle of the semester instead of at the end.

WORLD STUDIO AHMEDABAD 2020

For the fourth year, the World Studio proposed interventions to Ahmedabad, India. The specific intervention area selected was Gandhi Ashram, which has 27 informal settlements that shelter approximately 22,000 residents. The area was selected for intervention because of its location within the city and because it encompassed both existing informal settlements and vacant land, allowing students to decide whether to upgrade and expand existing settlements or to build new ones.

WORLD STUDIO OUTCOMES

VIRTUAL REALITY MODEL: IMMERSIVE ENVIRONMENTS TO REMOTE SITE VISITS

The site in Rio was very steep and not accessible to vehicles. In addition, its access by foot by anonymous visitors posed severe safety concerns. These issues presented a challenge for the studios in Rio that did not exist in Ahmedabad. We overcame this challenge by presenting the students with three immersive virtual environments (VEs), all with the same data content but

each offering a distinct immersive experience. The students were introduced to the VEs at the beginning of the studio and were asked to use them to support remote site visits.

The VEs presented 360-degree images and videos and a 2D plan of the Santa Marta favela. The locations of the images and videos were tagged on the plan, and the user could click on the tags to access the content. See Verniz (2020) for a more detailed description of the applications.

COMPUTATIONAL MODEL - THE ANALYTIC GRAMMAR OF SANTA MARTA

A computational model that provided a dynamic description of the formal structure of the Santa Marta favela was developed for the studios in Rio as part of an ongoing Ph.D. dissertation by one of the instructors. This model explained the settlement process by inferring shape relations via an algorithmic process supported by shape grammars. The settlement process of Santa Marta has been spontaneous and incremental. A nine-step procedure was encoded in the grammar to describe this process, with a given question answered at each step. Each step corresponds to a small set of rules that can be applied to address each question. The Santa Marta Urban Grammar has a total of 14 shape rules to locate, define, and shape each building, as well as the circulation and building entrance. Initial shapes are determined by the three settlement entrances that provide access to Santa Marta. See Verniz (2020) for a more detailed description of the grammar.

STUDENTS' PROPOSALS AND WORLD STUDIO ASSESSMENT

In this section, we present examples of student work in each year and a survey used to evaluate the adequacy of the computational tools available to the students in World Studio.

In 2017, World Studio focused on intervening in a built informal settlement. The students used Gouverneur's armature methodology to develop their proposals, according to which punctual interventions in selected sites of already established urban areas can trigger subsequent neighborhood transformations. In their final proposals, the students were required to present the rules of their intervention. Figure 2 shows an example of rules developed to identify the main circulation pathway and define the proposed intervention's steps.

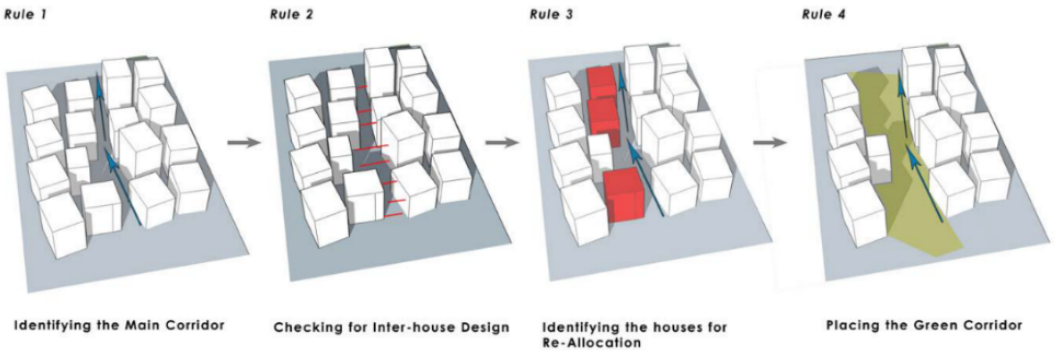

Figure 2. Rules developed by students to identify main urban corridors and propose interventions.

Source: the authors.

The students developed proposals for open areas, green pathways, community centers, civil buildings, and so on. Figure 3 shows a plan for intervention in a pathway. Existing buildings are represented in grey, whereas the proposed intervention is represented in green and beige.

v

Figure 3. Urban corridor intervention.

Source: the authors.

For the 2018 World Studio, the students were free to choose whether to create an extension on the eastern or the western side of the settlement. In addition to workshops on pattern languages and shape grammars, students had access to the Santa Marta Urban Grammar (VERNIZ & DUARTE, 2020), which they used as a reference to develop their proposals. Overall, these resources helped students to create patterns to compose the urban form of their proposals for extending the favela. Figure 4 shows a student proposal.

For the 2019 World Studio, the students' proposals focused on developing a new settlement in Rio de Janeiro. The students could choose one of three areas for intervention. As in the previous year, students were instructed on patterns and shape grammars and given access to the Santa Marta grammar. They also had access to an interpreter of the Santa Marta grammar (CASTRO E COSTA et al., 2019; VERNIZ, 2020). However, whereas the brief for the 2018 studio was to develop a proposal based on Santa Marta's urban pattern, in the 2019 studio, the students could develop their grammars, which allowed significantly more design freedom. Figure 5 shows one of the proposals for intervention.

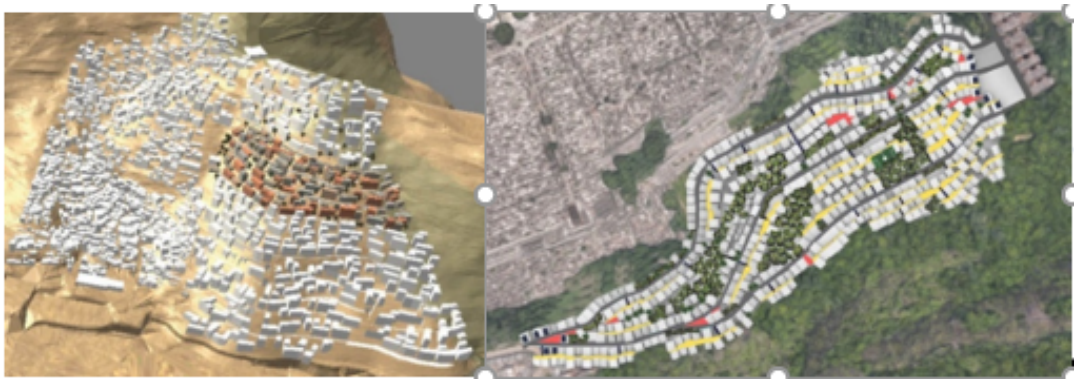

Figure 4. (left) Student proposal to expand the Santa Marta favela to the east.

Source: the authors.

Figure 5. (right) Proposed area for affordable housing settlement.

Source: the authors.

For the 2020 World Studio, the students modeled and evaluated the site conditions using Rhino, Grasshopper, and QGIS. They evaluated general characteristics such as pedestrian comfort, categorical density, and spatiality, as well as the specific construction qualities of existing building typologies.

One of the proposals divided the overall area into communities with a central space, resulting in a "ring road" connecting the community centers to improve circulation between the communities, the subdivision of communities into smaller neighborhoods, and the location of amenities along the ring road. Figure 6 depicts this proposal master plan (left), a view of one of the housing configurations (top-right), and a detail of the central green area (bottom-right).

Figure 6. Master plan (left), view of one possible housing configurations (top-right), and a detail of the central green area (bottom-right).

Source: the authors.

STUDENTS' EVALUATION OF COMPUTATIONAL TOOLS

One of the methodological premises of World Studio is the use of computational tools as a strategy to design environments that have some of the qualities valued in informal settlements, particularly formal complexity, urban diversity, and high customization, while avoiding their flaws, such as the lack of infrastructure and public spaces. At the end of the studios, students were asked to answer surveys on the technologies they used. We present the Ahmedabad survey results to understand students' experience and assess the role of computational tools in World Studio. Nineteen students responded to the survey. The survey results show that 75% of the students agreed that their Rhinoceros skills had improved (scored 3 or higher on the Likert scale of 0 to 5); 90% agreed that their Grasshopper skills had improved (scored 3 or higher); 90% agreed that their Rhinoceros skills had improved from good to excellent (scored 3 or higher); 65% agreed that their Grasshopper skills improved from good to excellent (scored 3 or higher); 95% agreed that using Rhinoceros and Grasshopper had been either very useful or extremely useful (scored 3 or higher) in the development of their designs; and 90% agreed that they intended to use Rhinoceros and Grasshopper in their next design opportunity.

DISCUSSION AND FINAL REMARKS

In all its iterations to date, the World Studio has focused on a teaching/learning computational approach to provide students with a targeted opportunity to engage in design processes by articulating shape grammars and parametric tools in a real-world international setting of informal settlements. Supported by extensive instruction, advanced technology,

and feedback from community members and local university faculty, the students engaged in creative processes that allowed them to understand the relationship between cultural aspects and the built environment and demonstrated the potential (and shortcomings) of new design media.

The computational design logic was a critical aspect of the teaching process. Most of the students agreed that their Grasshopper and Rhinoceros skills had improved through the studio experience. Further, students agreed that through the studio, their ability to develop their ideas had improved. In this sense, the students' answers reinforced our perception that the studio (and the teaching experience itself) contributed to the students' development in designing urban environments. Although a few students encountered some difficulty assimilating software content (Rhinoceros and Grasshopper), their work resulted in exciting proposals for the intervention site due to the computational approaches they developed. Further, it is essential to emphasize that it does take some time to become proficient with this teaching approach, given that it requires thorough knowledge of applying pattern languages, shape grammars, and parametric logics for urban design. It also requires some mathematical and programming skills to represent design solutions both algorithmically and visually.

Finally, we think it is crucial to use computational resources to design interventions in informal settlement contexts. They offer an essential tool to solve complex design problems. It is essential to include computational studios in architectural and urban curricula. The World Studio offers a viable model for this approach. In addition to the positive feedback provided by students, World Studio received great feedback from guest critics, local faculty, and communities, who considered student work was good and offered adequate, viable solutions to the needs of the people targeted in each iteration. This assessment provides very encouraging stimuli for using technology to aid creative design processes, leading to more inclusive urban environments.

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