ISSN 1828-5961

A Didactic Experience on the Use of a Parametric Tool for Multicriteria Analysis in Planning Education

Experiência Didática de uso de Ferramenta Paramétrica de Análise Multicritério em Disciplinas de Planejamento e Projeto Urbano

This paper presents the experience of use parametric tool for generate synthesis maps of multicriteria analysis in Urban Design courses of the Undergraduate Program in Architecture and Urban Planning at Pontifical Catholic University of Minas Gerais. The tool was made in Grasshopper and its interface in Human UI. The urban data were previously treated in ArcGIS. The maps generated were used in urban design assignments, supporting qualitative analysis for simulation of scenario to urban design. The study area was the Pampulha region in the city of Belo Horizonte, Brazil. As results, the paper discusses the pros and cons of the parametric tool which has been developed as well as the use of multicriteria analysis in urban design, focused on intra-urban and neighborhood scales.

O artigo apresenta o uso de uma ferramenta paramétrica de análise de Multicritério em uma disciplina de Projeto Urbano do curso de Arquitetura e Urbanismo da Pontifícia Universidade Católica de Minas Gerais. A ferramenta foi feita no Grasshopper e sua interface no Human UI. Os dados urbanísticos foram previamente tratados no ArcGIS. Os mapas gerados foram utilizados em exercícios de desenho urbano e suporte a análises qualitativa para simulações de cenários. Foi utilizado como área de estudo a regional Pampulha em Belo Horizonte, Brasil. A partir das observações da experiência didática o artigo discute os pontos positivos e negativos observados no uso da ferramenta desenvolvida assim como o uso de de análise de Multicritério em projetos urbanos, focados nas escalas intra-urbanas e de vizinhança.

Silvio Romero Fonseca Motta
Ph.D in Architecture and Urbanism (2014), Master in Civil Engineering (2009) end Bachelor in Arquitetura e Urbanismo (1994) from Universidade Federal de Minas Gerais - UFMG. Professor in Pontifical University of Minas Gerais and UFMG. Acting on the following subjects: parametric design, structure, sustainability and BIM.

Marina Salgado
PhD in Architecture and Urbanism from UFMG; Master in Built Environment and Sustainable Heritage by UFMG; Specialist in Urban and Architectural by UFMG; Graduated in Architecture and Urbanism from the Pontifical Catholic University of Minas Gerais. Works in the area of urban planning and design, landscape and cultural heritage.

Eduardo M. R. Bittencourt
Master's in Architecture and Urbanism from UFMG (2014), bachelor in Architecture and Urbanism from Instituto Metodista Bennett (2006). Assistant Professor I of the Pontifical University of Minas Gerais. Provides technical assistance to civil society and social movements in the mediation of territorial and urban conflicts.

Guilherme T. Muzzi de Sousa
Undergraduate student at Architecture and Urban Planning program at Pontifical Catholic University of Minas Gerais (PUC-MG). Currently is bolsista at PUC-MG. Has experience in the area of Architecture and Urbanism.

Jessye Ariane G. de Oliveira
Undergraduate student at Architecture and Urban Planning program at Pontifical Catholic University of Minas Gerais, degree of Clarinet by Artistic Center of Palácio das Artes (2016) and degree of lyrical singer by Municipal Music School Zé Fuzil (2014). Has experience in the area of Architecture and Urbanism.

Keywords:
didactic methodologies, multicriteria analysis, parametric tool, urban design.
Palavras-chave:
metodologia de ensino, análise multicritério, ferramenta parmétrica, desenho urbano.

ISSN 1828-5961

1. INTRODUCTION

Planning and Urban Design courses of the Undergraduate Program in Architecture and Urban Planning at Pontifical Catholic University of Minas Gerais use theoretical and quantitative analysis of the urban phenomenon to develop proposals for intervention in urban space (Santos & Duarte, 2008). The development of the information technologies applied to urban scale, commonly called as geotechnologies, allows the quantification of several data and the description of phenomena. The association of cartographic data to alphanumerics provided efficient and fast answers to the questions: "in this place, what are the particularities?" and "these particularities, where to find them?" (Goodchild, 1987).

The Geotechnologies can contribute to the development of school assignments in the planning education as well as for design purposes. The simulation of future land development scenarios is one of the main planning support methods based on Geotechnologies. These simulations can make use of Multicriteria Analysis in its methodologies.

The Architecture and Urbanism Undergraduate Program of the Pontifical Catholic University of Minas Gerais (PUC-MG) is traditionally known for its urban planning and design concentration areas. This paper presents an experiment [1] that use the geotechnologies in the urban design courses, as part of the pedagogical method, through the simulation of scenarios to support the decision of the urban project on territorial occupation using Multicriteria Analysis.

2. METHODOLOGY

The research method adopted in this work was the descriptive case study. This study objective is to raise information about the use of parametric tool to generate synthesis maps for urban analysis. The use of the tool happened in the Urban Design courses [2] of the Architecture and Urbanism Undergraduate Program of PUC-MG, in 2017 (school semester, february to july). So, the case analysis was made ex-post-facto, and tries to identify the tool benefits and it's generated maps by the design process.

The paper presents the research in three steps. In the first step the developed tool is presented, and its particularities, resources and possibilities are described.

In the second step the courses process is described: the class characteristics, the challenges, the stages, the procedures for using the tool, and the maps generated by the students during the building up proposals phase. The description is made from an interpretive point of view, which seeks to understand the reasons of real world processes of urban dynamics facts, analyzed by the students.

In the third step, the described facts analysis is made. This analysis doesn't have a wide explicative aim. It discusses the pros and cons observed, considering the expectations of the use of geotechnology and the challenges faced by the students in developing the diagnostic stages and the design of intervention guidelines.

The conclusion suggests possibilities for a suitable methodology to use the tool in academic assignments in urban design.

3. PARAMETRIC TOOL FOR MCA

3.1. MULTICRITERIA ANALYSIS (MCA)

The Multicriteria Analysis is a method that involves the reality decomposition into its main variables, followed by the grouping of these variables in simulations that produce context visualization as a base to a decision-making process. It is a method based on the logic of decomposing to recompose. The first remarkable applications of this method in space analyses are seen in Ian MacHarg's work, which made a simple overlapping of maps in the book "Design with nature" (1969). It is a common resource used when decisions on environmental crisis, political choices, strategic problems and actions in a territory planning are required. Its complexity is focused in the combination of different variables and in the integration of then according to different opinions, resulting in different scenarios for the same question. Its main objective is to support the choice of a particular scenario. The chosen scenario by the MCA is not the only one possible, but it is the one that; in face of the variables; from the arrangements made by the setup objectives; from the opinion of different participants of the decision-making process; for a determined space and time; it is the most suitable solution.

The main function of Multicriteria Analysis for Urban Planning is its ability to integrate spatial variables, using thematic maps, in order to find suitable places for the allocation of spatial resources or human activities. Multricriteria Analysis is an operational tool, based in multi disciplinary decisions through (or with the use of) mathematical logics of variables integration, supported by data.

These are the basic steps for Multicriteria Analysis is, according Moura (2014):

- Definition of objectives and applications in the use of the system.

- Organization of alphanumeric and cartographic data.

- Data processing for the composition of matrix representations (rasters) for analysis and representation of the potential distribution of the phenomenon.

- Definition of variable weights and values for its subtitle components.

- Integration of variables in Multicriteria Analysis.

- Comparison with the existing reality.

- System Calibration and return to the analysis phase.

- Construction of if/then scenarios.

- Preparation of proposals for intervention, management and establishment of restrictions.

After setting up the variable layers, the map algebra is made through the weighted average (Moura & Jankowski, 2016).

The main variables, those that involve the research objective, are composed in information layers. It is necessary to transform the variables into discrete elements (cells or territorial units of information) that will receive values according to their location in the territory and their characteristics in the study area. Usually they are composed in the form of rasters in which the territorial units are cells (pixels) defining their size according to the

ISSN 1828-5961

quality and resolution of spatial representation.

The set of variables should be organized in layers that have the same spatial resolution (cells, territorial units of analysis or even pixels of the same size) and the same area of investigation (spatial extension or delimitation of the analysis area), in order to allow the correct overlapping and combination of information. Once the representations of the elements, which may be a matrix or a set of unit representations, are made, they are combined by multiplying the weight of the variable by the territorial unit score. The overall value of the territorial unit (index of suitability) is the sum of the results of the multiplication of the scores by the weights in each of the layers. Figure 1 presents a diagram of a MCA layers process.

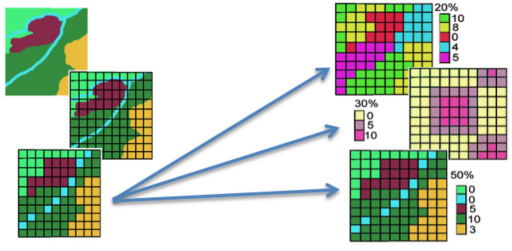

Figure 1 – Multicriteria Analysis Layers. Source: Authors, adapted from Moura (2014)Source:authors.

3.2. DATA PROCESSING

The initial files used in the tool can be .shp or .csv. Usually these initial files are prepared in the ArcGIS software, where each layer is modeled and the territorial unit score is assigned. The file (.shp or .csv) is up loaded into the Grasshopper algorithm, providing the entire georeferenced database for Multicriteria Analysis processing and visualization map generation. In this didactic experience, the following data layers were generated: transportation, accessibility, real estate dynamics, commercial use, urban dynamics and flood hazard areas.

3.3. GRASSHOPPER ALGORITHM

The tool used in the didactic experiment consists of a parametric model developed in Grasshopper software. The parametric model algorithm included the following steps (Figure 2):

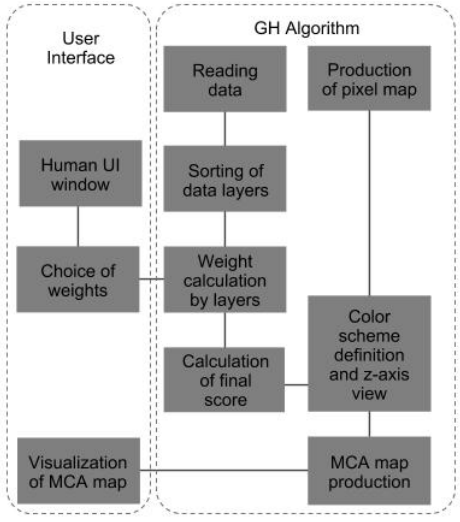

Figure 2 - Flow Diagram of Grasshopper algorithm stages. Source:authors.

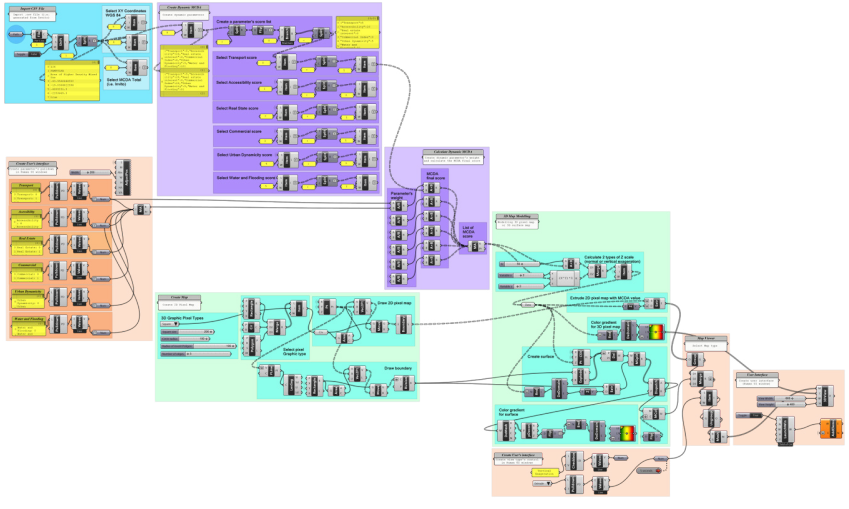

Figure 3 - Algorithm in Grasshopper's graphical environment. Source: Authors.

Figure 3 presents the algorithm in the Grasshopper's graphical environment.

The parametric model starts processing by loading the data layers generated in ArcGIS (transport, accessibility, real estate dynamics, commercial use, urban dynamics and flood areas) through .cvs file. In the .cvs there is the WGS-84 geographic coordinates attribute of each point and the algorithm reads this coordinate to model the initial points of the map (Figure 4).

Then the algorithm separates the scores of each layer and associates them at each georeferenced point (Figure 5).

The algorithm calculates the multicriteria analysis (MCA) from the scores of the georeferenced points. The tool purpose is to allow the user to simulate different weights for the MCA calculation. For this, a mathematical strategy was adopted to facilitate manipulation by the user. The value of weights of each layer is proportional (in percentage) to the sum of all weight values. This means that the value of a weight in one layer directly implies the percentage value of the weight of the others layers. To facilitate manipulation and understanding by the user, we adopted the strategy of defining an absolute value from 0 to 10 for

ISSN 1828-5961

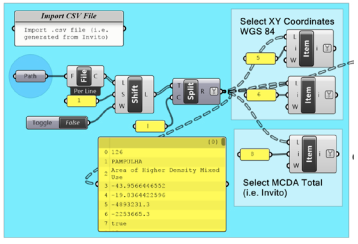

Figure 4 - Reading the csv file by the algorithm. Source: Authors.

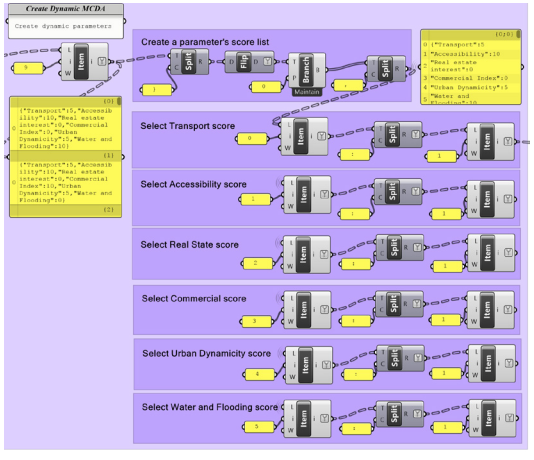

Figure 5 - Layer separation by the algorithm. Source: Authors.

the weights in each layer, instead of a percentage value. The algorithm automatically processes and normalizes the absolute values definitions, transforming then into the percentage values of the layer, considering the interaction of the values 0 to 10 chosen for the weights of the other layers. This strategy was called the dynamic calculation of MCA weights (Figure 6).

Parallel to the calculation of the overall value of the MCA, the modeling algorithm generates a map of the area from the georeferenced points. The .csv file prepared for the didactic experiment was done with points in a grid of 200x200 meters. Maps were generated from this base, placing a geometric representation

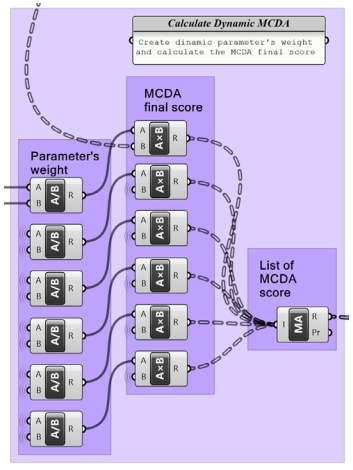

Figure 6 - Dynamic calculation of MCA weights. Source: Authors.

(pixel) centered on the points. The algorithm can use different types of pixels, such as squares, circles, or hexagons. A square pixel map of 200x200 meters was used in this didactic experiment (Figure 7).

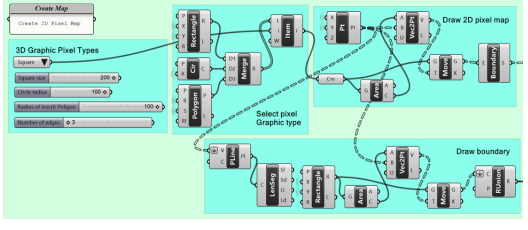

Figure 7 - Map Generation. Source: Authors.

The calculated overall value of the MCA is then associated with a map of colored pixels. The algorithm also allows the generation of visualization of the extrusion of the pixels, or the visualization of a surface, associating the overall value with the values in the z-scale. The study adopted a traffic lights color scheme (green, yellow, red, with low green values and high red values). Each pixel is modeled with a corresponding color of the overall value of the MCA. In addition, an option was made to display a map with a z-scale that uses pixel extrusion by associating its height with the overall value multiplied by a factor. This option is called vertical exaggeration. It is possible to apply a factor of 50 in the vertical factor. Figure 8 shows this step of the algorithm.

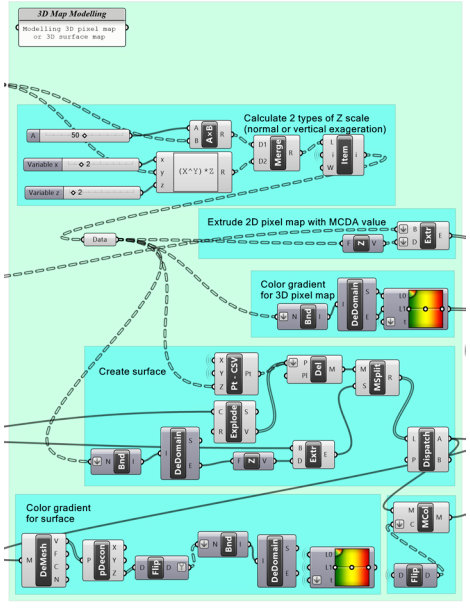

Figure 8 - Color scheme. Source: Authors.

The interface was then elaborated to manipulate the values of the set of weights and consequently, the visualization of the maps.

3.4. INTERFACE HUMAN UI

The tool interface was generated using the Human UI plugin. It is a window that contains: a scroll set to choose the weight set; a scroll to choose the pixel type; and a dynamic view of the graphical representation of the pixel map (Figure 9). The territorial units (pixel) with the largest overall value are represented by the red color, the smaller values by the green color, and the intermediate values by the yellow color. The pixel and map colors change according to the pixel type and weight set assigned by the user.

ISSN 1828-5961

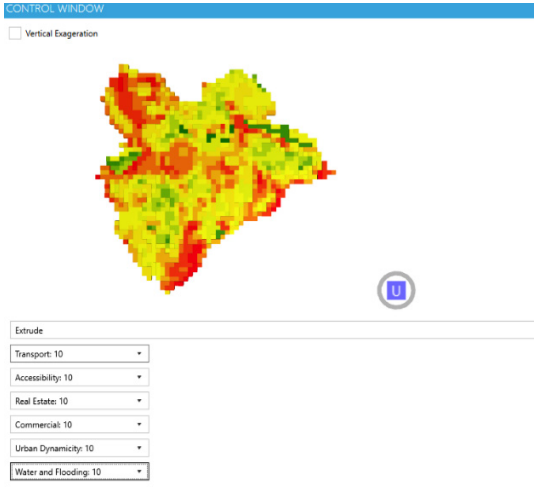

Figure 9 - User interface in the Multicriteria Analysis tool. Source: Authors.

4. DIDACTIC EXPERIMENT

The didactic experiment was made with 8th period undergraduate students of the Urban Design course of the Architecture and Planning Undergraduate Program at PUC-MG. The program structure consists of 3 subsequent cycles:

- Basic cycle: 4 period long [3]; theoretical and instrumental educations on the contents and competences required to the design process. Horizontal integration of courses made by a "Integrated Project".

- 1st professional cycle: 3 period long; learning contents on technology, architectural and urban theory, history and social science. Practical activities are experienced through design assignments.

- 2nd professional cycle: 3 period long, urban planning and architecture practice through design projects (or assignments) of medium and high complexity.

In second semester of 2017, the Urban Design course [4] was divided into two classes, each with 28 students organized into 7 study groups. The course aim was to work in different areas chosen within the perimeter of the Pampulha Region, in the city of Belo Horizonte. Pampulha Regional is one of nine administrative jurisdictions in Belo Horizonte and have 51,04 km² large and encompasses 43 neighborhoods. The selected study area used was the same as used in the previous period, when the inventory and guidelines for proposals were developed at the Urban and Regional Planning scale [5]. The purpose of keeping the same area is to take advantage of the more detailed knowledge about the region, to face the challenges of expanding the scale of studies, so that proposals reach the urban dimension of the neighborhood through planning strategies. The general objective of the course is to design a project of intervention in the urban space [6], based on the understanding of the place in terms of its current situation and potential in the structuring of the territory in which it is located as well as in terms of its morphology. The specific objectives are to analyze the desired urban development scenarios, the use and appropriation of public space, the areas morphology, the environmental, social and economic impacts of the proposed design, considering urban sustainability aspects, improving social inclusion and the adequate use of technologies (Santos & Duarte, 2008). For this, the course is structured in three modules:

a) The first module encompasses the following: an inventory of the study area; the choice of the intervention area (a place within the urban area); a critical analysis and understanding of the area's current situation (urban structure and morphology, urban regulation), its urban dynamics and potential transformation and definition of the urban design concept. The learning challenges at this stage are the use of diagnostic information, such as synthesizing the specific analyzes about the structure and the urban dynamics in the understanding of the reality that allows decision making on the central problem of the study area and the construction of a concept of urban design that supports the later stages of propositional character (preliminary study and preliminary design). In addition to knowing the complexity of the real and diverse urban universe present within the area, the student seeks to understand what is relevant in the neighborhood or place project scale, usually treated in the academic environment as something subjective [7] or of a theoretical-conceptual nature, without direct relation with the design tools studied until then in the course of Architecture and Urbanism. The work scale is the interior of the neighborhood. The urban space of these neighborhoods is treated from the sense of place or the urban environment, that is, it has as focus of action a dimension of the urban space present in the perception of the people of the place that is the result of the confluence between the physical attributes of the built environment, the activities carried out in this space and the conceptions (perceptions) produced by each one in his/her individual experience (Canter, 1977). These terms are used here from the disciplinary field of Urban Design, resulting from several theoretical frameworks in the elaboration of a theoretical methodological support that includes approaches of urban geography (Edward, 1996), spatial syntax (Panerai, 2006; Cullen, 1993; Lynch, 2010), urban sociology (Jacobs, 2011; Mongin, 2009) and psychology and other behavioral sciences such as semiotics and plastic (Rapoport, 1978). The theoretical studies conducted by the students in previous semesters are incorporated so that they are visualized and applied for a real urban problem. Real processes are developed that are inserted in a focused analysis, reduced in its territorial scale. The actions consider the four dimensions that determine the aspects of the urban environment in the daily life of Brazilian cities: the patterns of occupation and land use; the structuring processes of this occupation; the quality of the public space in the area; the characteristics and quality of vehicular and pedestrian mobility within neighborhoods.

b) The second module develops the Preliminary Study of Urban Intervention. At this stage, student groups spatialize the guidelines formulated at the previous stage in order to achieve consistency of concept with practical proposals The challenge is to turn ideas and concepts into design strategies and actions so that they can be developed in the next steps: What does a bad ambience mean on a street? What are the phenomena that determine this process? How to propose physical and functional transformations in private and public spaces for the configuration of a new daily dynamic? Which planning and design tools and techniques of, can be used to make these objectives feasible? This process is called proposal spatialization, when, at the

ISSN 1828-5961

same time that students are demanded for a domain and clarity in their conceptual intentions and their strategies of intervention, the proposals need to realize in the physical space, demanding that its viability is also represented through of spatial drawings and models with the definition of what is being designed for the study area. Another topic that has its practical development started is the design of instruments for implementation of the actions and proposals foreseen in the preliminary study. The instruments emphasize the application of urban policies foreseen in Brazilian urban legislation that seek the equitable distribution of the damages and benefits of urbanization through planning operations and public-private partnership involving residents [8], investors, real estate producers and landowners (capital appreciation urbanization, contribution of improvements, urban operations, real estate consortiums, transfer of development rights, grant of constructive potential and uses, etc.).

c) The third and final module develops urban design schemes and proposes strategies for their implementation: principles of urban draw, urban development typologies, new urban design criteria, details of public spaces, etc.

The multicriteria analysis tool was presented when students finished the first module. At this stage the inventory was completed and the concept defined. The use of the MCA tool happened in 2 stages. In the first one, the group of students chose the layers to be used and defined the weight (0 to 10) of each layer. The choice of at least 3 layers for MCA was required. The choice should be justified and based on information of the diagnostic and the concept. As much as possible, the set of layers could be an investigation of the doubts perceived in the previous diagnosis and conceptual phases.

At this stage it was possible to perceive some difficulties, usually related to the attribution of weight for each layer. For example, a group that had the densification of the area as the main issue, made three MCA maps. In each MCA map, they chose a different set of layers. On map 1, they defined: constructive potential available (weight 10) X commercial use (weight 10) X dynamic real estate since 2010 (weight 10). In map 2, they defined: transport (weight 10) X accessibility (weight 10) X constructive potential available (weight 10). And on map 3: commercial use (weight 10) X accessibility (weight 10) X transport (weight 10). According to the justification of the group, the criteria for the investigation with the MCA were intended to evaluate areas suitable for densification considering existing commercial use, available transport, area accessibility and future constructive potential. For this, the group decided to make 3 maps, always with the weight 10, instead of changing the weight.

Other groups have decided to isolate specific layers to see their separate behavior. It was also observed groups that defined weights with close values, such as 5, 6 and 7. However, it was also observed groups that explore more the possibility of weight change and made several options with significant values of difference for the same set of layers.

The MCA maps of the weight options were made by the researchers and presented to the students for the second stage of the use of the MCA tool. The second stage was the analysis, validation and use of MCA maps by the students. In this stage some important question were brought by the students:

- There was difficulty in verifying the geographical scale. Ideally, the pixels of the raster image would have a larger scale resolution (smaller cells). In the experiment, pixels corresponding to 200x200m were used.

- There was a need for places and objects of reference, such as the geographic north, Pampulha lake, the airport, the zoo, among others. This would facilitate the location of each specific area of intervention

- The students perceived a divergence between the simulation and reality. For example, the commercial layer pointed to some area that, in fact, are residential areas. This divergence may be related to pixel resolution that includes a large territorial unit that excludes non-major uses. The course requires a high scale with higher details, such as a avenue, for example. Only the transport layer was compatible with the reality obtained by all groups. In all other layers, differences were perceived at higher or lower levels [9].

- The color of the gradient used (red to green, with transitive values in yellow) requires an improvement and more explanation. There was no caption and the students were confused. In some situations the red color was related to bad results and in others to good results.

- The students suggested new layers to be included, such as: green areas, residential and mixed uses, etc. This could help the course's specific work.

From the maps generated by the MCA tool, it was possible to compare if the data collected systematically by the students in the inventory and analysis stages were in agreement with the scenarios suggested by the tool, which uses georeferenced data. The figure 10 presents the dynamic used in the presentations and the printed work made by the students.

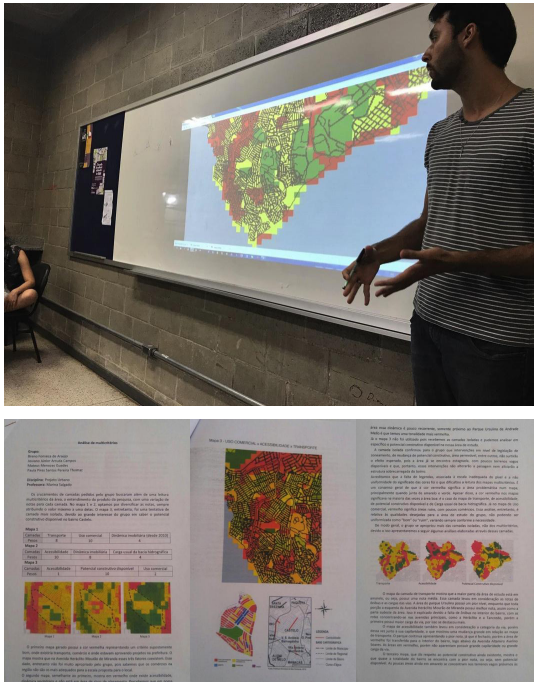

Figure 10 - User interface in the Multicriteria Analysis tool. Source: Authors.

ISSN 1828-5961

5. RESULTS AND DISCUSSION

The composition of the MCA layers by students during experimentation shows that understanding the basic layers was not the same for all. For example, some groups that sought to analyze a scenario related to car impact on mobility, chose only the transport layer rather than exploring other significant layers such as accessibility (which is important for the impact on mobility and could show data as distances traveled within the neighborhood, or density of the road network) and others. The wide range of different results and divergences perceived with the geoinformation produced, generated a typical problem in experiments that use geo-processed information in the urban analysis that is to ask something for a wrong layer and, as a result, obtain a different response than what is expected. The lack of time for feedback and revision of the modeling (crossing of basic layers, set of weights, hypotheses and specific interests in the MCA) also affected the students' appropriation of the tool. It is necessary to improve the manipulation of the MCA tool in a more accessible way, to avoid the need to cross data after defining the MCA criteria and to avoid the waiting time between the expectation (diagnostic question) and the possibility of appropriation (confirmation of hypothesis of design or intervention) by the groups for the design.

By the perception of students and teachers involved in the use of Multicriteria Analysis to support the decision of the design process it was possible to suggest some possibilities of improvement in the experience:

- appropriation by the student of the MCA maps in the first stage of the course, allowing that the map data contribute to a qualitative characterization of the area and to the construction of a higher detail concept of intervention.

- guarantee of a longer time in the schedule of the course so that the activity can be discussed by the professors and students and among the students of each group.

- enhance of the visual and cartographic aspects (generated images resolution, territory representation, discussion about the data that compose each layer)

- the possibility of adopting a second stage of using the MCA to generate maps focused on the support for the decision making in the schematic design stage.

- longer time to follow-up the processual development of the design in classroom by the research team to approach the specificities of the processes in the elaboration of the urban design.

6. CONCLUSION

During the process of using the Multicriteria Analysis tool in the urban design course, it was noticed the need for some adjustments, mainly in relation to the adaptation of the bases presented to the reality of the scale used in the course. This scale is related to the scale of the neighborhood, being necessary that the information must correspond to the level of roads, lots and blocks, for example.

Despite the need for some technical adjustments to the tool so that it can contribute effectively to the urban design course, it is emphasized the importance of the use of georeferenced data both at the diagnostic stage and at the propositional stage as a valuable tool that, in addition to enable a more in-depth reading of the reality of a region, is still decisive in the decision-making stages, influenced both in an effective way [i].

The application of this research in the course has a theoretical-methodological objective, to improve the teaching and learning of urban design, promoting the intersection between urban design and draw methods. In the study case, before the experience related, the methodology adopted in the course was based on methods that prioritize the environment perception and the morphological analysis of the urban structure and the urban dynamic: figure-backgrounds maps, field trips, serial vision, mental mapping, interviews, use and occupation mapping, priorital routes for vehicles and pedestrians, typological patterns of the building environmental and free and public spaces, etc.).

Thus, the MCA method was included in the course in order to extend the reading and interpretation of the urban space typical of territorial physical planning, while incorporating, mobilizing and associating the variables present in the interactions between elements and processes in the study areas. This allowed the maintenance of the main objective of the course and the urban design that is to elaborate proposals that prioritize the quality of the place and the urban environment, going beyond the simple use and organization of the land use and design criteria of a territory, increasing the understanding of the combination of the variables and their results and possibilities of intervention in urban places. It would be important to mention that, as mentioned before, the analytical tools, even representing a significant contribution to the urban analysis, do not replace analyzes carried out in, for example, fieldwork, surveying residents' perceptions among others. It is important to mention that even representing a significant contribution to the urban analysis, the analytical tools do not replace analyzes performed in, for example, fieldwork, surveying resident's perceptions, among others.

MCA still requires new experiments for practical use in urban design. In this case, it contrasts with the usual practice adopted by the traditional design process, widely used in undergraduate architecture and urban design in Brazil. This process guides the design learning, regardless of its complexity, by successive steps: ASSAY (answers to the problems) > TEST (solutions) > CHANGE (products) > NEW ASSAY (review) and if the hypothesis is confirmed: REPRESENTATION (of solution) > DEVELOPMENT > RECONSIDERATIONS > and forwarding for a REASONABLE FINAL SOLUTION (Zeisel, 1984). In urban design practice, this tradition must be continued through the adaptation and improvement of the relationships of those involved (public agents, academic-scientific agents, society). As urban society advances, contradictions and fragmentations are amplified in territory, space and everyday life, making it necessary to incorporate faster, more flexible and less subjective instruments and strategies. With this, design practice is strengthened, even if its traditional methods are maintained.

Therefore, contemporary spatial production requires traditional bases of understanding of the area and investigations that include quantitative analysis of the multiple variables of its main characteristics. For this purpose, the use of the Multicriteria Analysis tool in the urban design course, as demonstrated in the didactic experience described, meets this new requirement, trying to understand qualitative aspect of the analytical

ISSN 1828-5961

categories, especially through the organization of parameters relevant to the future urban design scenario. It is necessary to emphasize the importance of adding qualitative analysis to quantitative analysis of the space for the analysis of the urban phenomenon.

7. ACKOWLEDGEMENTS

We acknowledge the support of CNPq – National Council for the Scientific and Technological Development, through the research MCTI/CNPq/MEC/CAPES 401066/2016-9 and FAPEMIG - Fundação de Amparo à Pesquisa do Estado de Minas Gerais, for the support in the research FIP 2017/432-S1.

NOTES:

[1] This experiment was developed as part of a research project supported by the Minas Gerais Research Support Foundation (FAPEMIG).

[2] The Urban Design course has 102 hours / classes distributed as follows: UNIT I (09 hour): Presentation of the course and practical work. Complementation and consolidation of information about the study area. Definition of the intervention area. UNIT II (39 hours): Development of the Preliminary Study of Urban Intervention: understanding the current situation of the area (structuring, urban form, urban legislation) and the trends and potential of its transformation. Formulation of spatial intervention guidelines. UNIT III (54 hours): Development of a draft urban design and its implementation mechanisms: urban design principles, urban form configuration typologies, urban policy instruments and their application, impacts of urban interventions, treatment details public areas. Since the proposed methodology was applied at the end of Unit II.

[3] A period corresponds to six months.

[4] This course last one semester.

[5] This change of scale occurs from one semester to another from the moment in which the courses change and consequently their objectives change too.

[6] The object of study analyzed in the previous course was the regional Pampulha. For the Urban Design course, the school assignments of the groups are based on the scale of the neighborhood and the choice of a specific area.

[7] It is necessary to clarify that we are not excluding, not even subjugating the subjective reading of urban analysis; we are just adding an objective reading to it.

[8] Their participation occurs mainly through the analysis and perception of their desires in relation to the modifications of the landscape where they are inserted.

[9] This level refers to the intensity of occurrence of the layer in a certain area.

[10] It is important to emphasize that the georeferenced data contribute significantly to the reading and the understanding of the space, although they are not used independently, but in addition to other methods of space analysis.

REFERENCES:

Canter, D. (1977). *The psychology of place*.

Cullen, G., de Macedo, C. L., & Correia, I. (1983). *Paisagem urbana*.

Edward, S. (1996). *Thirdspace: Journeys to Los Angeles and other real-and-imagined places*.

Goodchild, M. F. (1987). A spatial analytical perspective on geographical information systems. *International journal of geographical information system*, 1(4), 327-334.

Jacobs, J. (2011). *Morte e vida de grandes cidades*. Martins Fontes.

Lynch, K., & Camargo, J. L. (2010). *A imagem da cidade*. São Paulo: Martins Fontes.

McHarg, I. L., & Mumford, L. (1969). *Design with nature*. New York: American Museum of Natural History.

Mongin, O. (2009). *A condição urbana: a cidade na era da globalização*. Estação Liberdade.

Moura, A. C. M., & Jankowski, P. L. (2016). Contribuições aos estudos de análises de incertezas como complementação às análises multicritérios-"Sensitivity Analysis to Suitability Evaluation". *Revista Brasileira de Cartografia*, 68(4).

Moura, A. C. M. (2014). *Geoprocessamento na gestão e planejamento urbano*. Interciência.

Panerai, P. (2006). *Análise urbana*. Editora UnB.

Rapoport, A. (1978). *Aspectos humanos de la forma urbana*. Barcelona: Gustavo Gili, 1995-2001.

Santos, R. E.; & Duarte, A. P. (2008). *Curso de Graduação em Arquitetura e Urbanismo* - Projeto Pedagógico

Zeisel, J. (1984). *Inquiry by design: Tools for environment-behaviour research* (No. 5). CUP archive