Architectural Representation Software: a Design Tool

Sergio Manes
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In the last decades, design processes have been approached with absolutely new representation techniques: digital media. This new tool was naturally incorporated to the architectural task not only in universities but also in Architectural offices. However, their evolution and utilization have been so sudden that their impact on the design object could not be properly assessed. Simply they stated to be used by translating analogical representation techniques into the digital media. In the Latin American context, in which the media interaction paradigm has not yet been completely established within universities and teachers, this work presents an exploration of the underlying ideas contained in the architectural representation software, as well as a series of exercises intended to teach how to use digital media as a design tool, instead of teaching how to use them as a mere representation tool.
I. Introduction

The ever-increasing development of different CAD and rendering software programs and their massive use by architectural offices and universities, has progressively replaced analogical media. Although there is certain interaction at the beginning of the design process, sooner or later there will be a breaking point in the media interaction process, in which the designer chooses the analogical or the digital media in order to finish off his design [1]. In recent times users prefer digital media in order to finish such process. And at this point we may pose the following question... When does the design process begin and when does it end? A priori, we may venture an answer and state that such process begins with a generating idea and ends with the materialization of the design object [2]. The development of a generating idea is what we call design process. As the idea goes through different stages from abstraction to gain more and more materialization, it acquires or assimilates other design ideas contained in the new contextual factors that appear as the process goes on. At times, these ideas complement the original one, and enrich it, sometimes they suffocate, deviate or substitute it, consciously or unconsciously, according to the particular process nature [3]. In this process of translation of creative ideas into shape, representation instruments play a key role (though generally unnoticed) by providing their own built-in biases to the design. The designer skill consists in recognizing these biases within different instruments and in choosing the appropriate instrument for a given creative idea and design object. One example of this, which is not only very evident, but also very clear, could be the following: during the process of design G. Rietveld must have been sketched the Schröder-Schräder house with rulers and squares rather than with French curves. Both if the designer recognizes these capacities of instruments and uses them to enrich the design process, or if he fails to notice them and uses instruments ignoring the influence of the media used upon design, representation tools constitute design tools, which enhance design, in favour of the designer, or modifying the development of the original idea, without the conscious consent of the designer. Julio Bermudez and Kevin King convey this concept in the second position of Hypothesis 1 of their paper entitled “Media interaction in the design process”, as they explain how designs made with certain digital tools, inevitably end up acquiring different appearances according to the tools used “...The shortcoming is a decreasing attention to the social, contextual, and programmatic aspects of buildings. Put differently, the sensuality of digital depictions begins to bias the process towards an aesthetic formalism (i.e., the Form -Z look, the 3D Studio look, etc.)” [1].
2. The role of representation tools in the design process

At this point, we could state that any representation tool (analogical or digital) is a design tool, in other words, we recognize certain qualities or potentialities in the different instruments, which can help or block the development of the creative idea. These potentialities we will call built-in design biases. The role of instruments in the design process is the same that the role of materials or constructive elements during the materialization of the design. In fact, both construct or materialize an idea. Representation instruments materialize the idea in order to approach the final design, materials and constructive elements materialize the design in order to approach the built work. The Einstein Tower by Enrich Mendelssohn is a clear example of this … A building meant to be built in reinforced concrete, was finally built in brick, due to the complexity of the moulds and their regular geometric will. (The will of brick, bent to be brick. Louis Kahn) [4]. The original drawings by Mendelssohn clearly reveal the tool he chose to materialize his creative idea: charcoal and Indian ink. Could we imagine the resulting Einstein Tower had he used AutoCAD as an instrument for translating his idea into shape…? or 3D Studio…? or else, among the analogical tools… a 0.5 mm 4H pencil…? wood…? As regards to building, same thing happens… Think of the Einstein Tower built with reinforced concrete… It may have been possible… with a greater cost due to the technological difficulties… Mendelssohn could have also used CAD to model his building (had it existed in that time), but he would have forced the instrument into generating something it was not meant for… something which it was not prepared for… and certainly in such a translation process from ideas into shape, the tool (CAD, in this case) would have triggered its own contained ideas, transferring them to design process, and finally the design would have been different from the one that was actually built. Definitely the ideas contained in instruments, as they are triggered, modify the designer’s original idea at his expense. A clear reference was made in the workshop “Between Digital and Analog Civilizations: The Spatial Manipulation Media Workshop” [5] as to the recognition of the ideas contained in the different digital media when consciously avoiding the use of CAD programs and when promoting the use of image manipulating and video software.

3. Crisis opportunity

It is worth considering that digital media are absolutely new tools, in comparison with the ancient analogical representation techniques, which are still being used nowadays. In this sense, both the applications of analogical techniques in digital media, and the revolutionary attitude involved with the new digital world, ignorant of any analogical vestige, are edges of a huge action field to be investigated and developed. The appearance of CAD has
introduced a breaking point in the exercise of Architecture. Limited in some cases to the development of ideas elaborated by traditional means, turned into a thinking device in others, its incidence in the design process and in the built results has not yet been assessed sufficiently [6]. This breaking point which, a priori, could be called the end of the hegemony of the analogical era (at least as we knew it at the time), marks the beginning of a new era in the architectural thinking. Architecture is undergoing a crisis because of the growing power of what is virtual [5, 7, 8]; and this crisis we are going through is not maybe a grieving, unsolvable situation, but on the contrary, a starting point for new developing horizons [6, 9]. It is now, in this critical moment, when the architect must meet the exploration of the digital interface head on, which is causing a paradigmatic change in our civilization [5].

The appearance of new technique (digital media) does not imply deciding for the new or for the old. It means interpenetration between both. It means an interaction between analogical media and digital media.

4. Teaching how to use the digital tool: the Latin American situation

The question of how to approach the teaching of the different software should focus on the systematic exploration of the built-in design biases of the digital tools. The incorporation of Computer Architectural Graphics as a subject, or the various names which the teaching of digital techniques may assume, cannot by any means be severed from design tools; because they are one and the same thing. Media are to be found within design [4]. It is impossible to separate them from each other; they simply go together. To design is to translate the creative idea into shape [3]; and this translating process is brought about by representing the shape which will finally become the design object. However, the importance of digital media in the design area is not equally recognized in the whole Latin American university community. The actual way in which the subjects related to digital media have been incorporated to the already existing traditional subjects in different Architecture Schools (undergraduate programs) in Latin America, reveals how important these new subjects are considered to be. We could distinguish the following levels of teaching the subject:

1. Media interaction and design processes teaching: Doubtlessly the most desirable teaching level, but unfortunately the least extended. Indeed very few universities support this kind of teaching. Except for very few cases (Universidad Nacional del Litoral, Argentina, for instance) it is carried out in laboratories, or in elective subjects, with a limited number of students. Digital media are not considered as mere representation tools, but as fundamental design tools, and therefore, are not taught as simple rules or drawing procedures, but as design processes, idea translating processes, interaction processes...
with analogical media in workshops and seminars with invited professors from abroad.

2. Operation manual teaching: This is the most common level reached by universities in which these subjects are obligatory. In this case the subjects consist in informing the functions of the new representation tool. Teachers in this situation start exhaustively informing every option of the command line, then every option of the command arc, and so on. It is just a mere translation of analog into digital processes, which encourages the use of digital media as a simple representation tool. This is a big mistake. Digital media should not be considered as mere representation tools, but as fundamental design tools, and therefore, should not be taught as simple rules or drawing procedures, but as design processes, idea translating processes and interaction processes with analogical media.

3. Introduction to computing: The subject is just an introduction. A few basic Windows, Microsoft Office, Autocad tools are presented as a starting point and students are expected to find out the working processes by themselves.

4. Elective subjects: Some universities include among a wide range of elective subjects, some subjects related to digital media, but only a limited number of students can attend them, according to the number of computers available. In this category we can find a wide variety of possibilities: some are laboratories, which are deeply involved with the new paradigm (Universidad de Mar del Plata), but we can also find subjects of type 2 (operation manual) or 3 (introductory).

5. Just nothing: It seems incredible that still nowadays in Latin America, many universities do not offer any kind of contents on digital media in their curricula.

Not always the academic conditions are optimal for the development and implementation of new instrumentation and design techniques. In Latin America, state universities function on really low budgets, which generate a considerable deterioration in the teaching and application of new digital media. In private universities, this situation is considerably better as regards technology, but unfortunately media interaction is not yet a conscious concept for teachers and academic curricula systematically disregard the increasing request of some teachers and researchers in this area.

It is clear from the above table that digital media are not considered to be very important in most Latin American universities. In most cases, Computing is added to the curricula as a new subject, completely detached from the design subjects, and it is often called names which seem to have no relation with the Media Interaction Paradigm, such as Introduction to Computing, Using Computers, and so on. Sometimes the subject is not even
obligatory, and students can choose whether to attend it or not. Sometimes the subject is assigned little class time, as if it was a trivial subject! (An average of 2 hours per week) This is a big mistake: to take away the necessary time for the teaching of a subject which is the leading role of a new era in the history of Architecture, to give it to other contents which only reinforce the techniques of the past. A material interpretation of Architecture is no longer enough in a world in which the power of the virtual (communication and information media) leads contemporary culture [5].

Another problem arises when the amount of time assigned to the teaching of digital techniques during university education in Architecture or Design, is placed at the end of the career, that is, when students are more mature and have a larger cognitive and skill repertoire [10].

Considering digital media and the interaction with analogical media as design tools, and taking into account that digital media are those which supply new techniques and processes of idea translation, makes it necessary that the implementation of this teaching start at the very beginning of the career, when the student faces the process design as a new experience, and has no previous experience either in the analogical media or in the digital media. In other words, when the experience he has in both media is practically the same [11,12,13,14].

5. The exercise translated into digital language

5.1. Introduction

The present work originated in a type 2 subject situation, according to the categories we have already mentioned, in other words an annual subject in the first year of the Architecture career, which was incorporated to the curricula in 1995. During the first two years the subject condition was purely type 2; it consisted mainly in teaching the repertoire of AutoCad and 3dStudio commands. The results of those first years of teaching were rather poor. Then little by little the subject acquired a new profile through the incorporation of design exercises, originally translated from analogical design explorations, which since 1997 have gained complexity, development and architectural interest as the students themselves discovered and exploited the built-in biases enhancing thus the final design. These built-in biases were

<table>
<thead>
<tr>
<th>Universities</th>
<th>%</th>
<th>Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>28.0 %</td>
<td>They do not have any subject on digital media.</td>
</tr>
<tr>
<td>5</td>
<td>8.3 %</td>
<td>They have an elective subject, which lasts 1 semester.</td>
</tr>
<tr>
<td>21</td>
<td>35.0 %</td>
<td>They have an obligatory subject, which lasts 2 semesters.</td>
</tr>
<tr>
<td>7</td>
<td>11.6 %</td>
<td>They have an obligatory subject, which lasts 3 or 4 semesters.</td>
</tr>
<tr>
<td>3</td>
<td>3.0 %</td>
<td>They have an obligatory subject, which lasts 5 or 6 semesters.</td>
</tr>
</tbody>
</table>

Table 1. Of a total of 60 Architecture Schools surveyed [17] (public and private from Argentina, Brazil, Chile, Mexico, Peru and Venezuela) these are the results
revealed through short design exercises, especially meant for research purposes, originally created and applied in the Instituto de Investigación y Diseño (Research and Design Institute) directed by César Naselli and later developed, translated and evolved into digital language in the Instituto de Investigación Infográfico-Arquitectónicas (Infographic – Architectural Research Institute), both pertaining to the same university (Universidad Católica de Córdoba – Argentina).

5.2. Information about class
The exercises we will now describe were made by students of the first year of the Architecture career (17, 18 year-olds), working in pairs in each computer (36 students per class, 18 computers), with one Professor and one Teacher. They were developed during 22 weekly classes of 3 hours each in the morning (9:00 a.m. to 12:00 p.m.). Each exercise was intended to discover, explore and exploit one particular built-in bias by creating an architectural object or space. Up to the year 2003 exercises were executed with Pentium 2 with 128 MB RAM, and the software used was basically Autocad 14 and 3DStudioMax3.

Each exercise was preceded by a short introduction to the commands required to develop it, in order to rapidly reach a comfort zone [1] appropriate for the work, a brief explanation of the exercise development and a layout of its purposes. Usually, this introduction would not take more than 45'. Finally, the exercise was developed and completed in the remaining time (2 hours and 15 minutes).

5.3. Built-in design biases
In this phase, the following built-in biases were detected, which were used in relation to a design object. Some are only commands but, potentially they are ideas to be used in the design process.

<table>
<thead>
<tr>
<th>Built-in Bias</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Orthogonality</td>
<td>CAD programs strongly tend to orthogonality. Unskilled users adopt this suggestion made by the digital media as sound ground to stand on. The complexity of the procedure to follow in order to change into alternative coordinate systems causes many users to keep using the original coordinate system. Therefore, the resulting space acquires a strong tendency into the orthogonal (Figure 1).</td>
</tr>
<tr>
<td>Level Plan</td>
<td>Another idea which is triggered as soon as we get down to drawing is the level plan concept. Any construction made on the XY plane tends to grow upwards or downwards as from level 0. In turn, a ‘view’ of projecting in plan (pictorial media) immediately spreads into the digital media. This problem can be tackled by indicating...</td>
</tr>
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Table 2. Built-in biases detected

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multi-viewport construction for the exercise, in other words, in all viewports at once, thus systematically avoiding the use of plan view (Figure 2).

Boolean operations The digital manipulation of volume allows us to combine different volumes in our work, whether by means of intersections, subtractions or unions. Things which could not possibly be quickly tested when using analogical media, are readily and spontaneously possible when using digital media. This enables us to quickly assess different combination possibilities among two or more objects (Figure 3).

Complexity The possibilities of using large amounts of information at once and the possibility of instantaneously creating and modifying objects, bring about highly complex volumes, sometimes lacking a supporting order (Figure 4).

Cloning Multiple repetition of any element or spatial cell is quickly obtained (Figure 5).

Instance The clone-instance mode (3D Studio-Max, 3D Studio Viz) permits us to create copies of an object or spatial cell, spreading the properties and modifications to all the other instances, in other words that growing one box the others will also grow (Figure 6).

X-form X-form is a modifier (3D Studio-Max, 3D Studio Viz) which enables us to link their positions relative to space, rotations, scale changes, within instances of the original object. For instance, if we previously rotate and move a box into space, and then apply the x-form modifier to move or rotate it, this will cause the movement or rotation of all other instances round their own axes (Figure 7).

Symmetry Although it is true that the possibility of generating geometric orders from symmetry axes or planes is too obvious, 3d symmetry presents not only very unusual symmetry planes, as for instance the xy plane, but also endless alternative symmetry planes which are not contained in the 3 main axes (Figure 8).

5.4. Development and evolution of the design exercises

We will now describe some of these exercises, which belong to a series called “From a priori space to kaleidoscopic space”. Each one is an evolution of the previous one.
5.4.1 A priori space (I) – The analog model

The a priori space problem consists in the design of a volume, which is then subtracted from a greater volume which contained it, and gives as a result an inverse space of the original volume [15]. This project exercise takes the space before the limits that will later materialize it. In this way it is possible to operate on the space geometry as a design object, instead of as a result of the manipulation of the limits that define it. So in this way, once the space volume has been defined, we proceed to generate through plaster cast, what will become an inverse space of the original volume (Figure 9 and Figure 10).
5.4.2 A priori space (II)

The exercise starts just like the analogical version. We start, then, generating the space that will originate the final space. By using orthogonality, creation of boxes and Boolean operations, the volume of the resulting space will be designed (Figure 11). Finally, we generate the volume which will contain the space and the original volume is subtracted from it. Once the void has been generated, we proceed to explore the space generated by means of cameras, in which the criteria established as design tips, are assessed.

Figure 9. Left: An outside view of an analogical model of a priori space. Middle: An outside view of an analogical model of a priori space. Right: A student exploring the inner space

Figure 10. Left: an a priori space sketch. Middle and Right: A priori Space materialized with polystyrene and acrylic

Figure 11. The volume of the final space and the generated inner space
5.4.3 A priori space (III)
In this phase of the exercise, the original volume is copied and slightly rotated (no more than ten degrees) on the construction’s three main axes. Thus we will obtain two objects: one orthogonal and the other rotated in space. Without displacing them from their original locations, we proceed to intersect both volumes (Figure 12). The result is absolutely uncertain, spatiality in this case has been proposed through the built-in biases of the chosen software (3D Studio max), based on a previously designed object. The high complexity of the space obtained, arises from using a very simple operation (rotate + Boolean), unthinkable in its totality. The student finds himself exploring an object which has been designed in collaboration with the digital tool.

5.4.4 A priori space (IV)
In order to get more clarity and simplicity as regards space generation laws, a spatial cell was created, which, in turn, was connected to other similar cells to generate a particularly complex object, in spite of the fact that the point of departure was a couple of very simple elements (Figure 13). Finally, this object was subtracted from a geometric body, and a space was generated, which had a surprising spatial richness, with plenty of aesthetic value. Then this unknown space was discovered through exploration, recognizing in it a kind of geometric labyrinth.
5.4.5 A priori spaces (V)
In this case the starting point was a space defined by a simple geometry. The exercise gained complexity when the void generated was doubled, displaced and underwent some kind of deformation (move, rotate, scale), and when both solids were merged, the original space was transformed (Figure 14). The exercise consisted in predicting the space which would result after the modification and comparing the obtained space with the predicted space.

5.4.6 A priori spaces (VI)
The utter relation between laws simplicity and exercise complexity that we have achieved by using digital media for the development of this kind of spaces, is that in which the space is defined as from a single piece, successively repeated and modified until the final space is generated. In this case we used an “L” as a primary element. This original piece was copied four times, and these copies were in turn cloned, in the instance modality (Figure 15). Instance is a 3D Studio Max copy option, which generates a twin object from the original one. This twin object is modified by modifying the original. So we can manipulate an original element and affect at the same time all the elements created from it. It is worth mentioning that this modality takes action only with modifiers, and does not work with transformers (Move, Rotate, Scale), unless we use the X-form modifier. In this way we can interact within the final space modifying just one piece which affects the whole space.
5.5. The Kaleidoscopic space

5.5.1 The analog model

Kaleidoscopic is another design exploration exercise which, together with a priori space was developed in the Instituto de Investigación y Diseño (Research and Design Institute) as an exercise made with analogical media. In the beginning it was nothing but a neoplastic composition meant to discover the contained spaces existing among its components (Figure 16).

The translation of this exercise to digital media opened up a lot of different results which could be obtained as from the interaction of simple laws. The incorporation of movement (digital animation) created a new cinematic space in which the elements that define spaces can vary in their position, dimension, material, etc., thus modifying the resulting space endlessly.

5.5.2 Kaleidoscopic space (I)

This exercise is an evolution of the previous ones. Due to the representation software potentialities, we can now approach further complexity which would be unimaginable with analogical media. Many copies of a simple pattern making a basic spatial cell and its respective repetition with the instance made by means of three-dimensional symmetries, allow us to finally generate a symmetric 3D configuration (Figure 17) and, the subsequent modification as from just the transformation of the disposition and the volume configuration of the original pattern, allows us to articulate the space like a three-dimensional kaleidoscope (Figure 18).
5.5.3 Kaleidoscopic space (I-b)
This exercise is similar to the previous one, but pieces, instead of being transformed, are moved or rotated applying X-form (Figure 19).

5.5.4 Kaleidoscopic space (II)
The spatial order established according to the disposition and repetition of the original pattern is now replaced by a completely arbitrary and chaotic disposition (within certain laws) (Figure 20) to generate, as from the same pattern, a completely different spatiality, as regards the one in the previous exercise (Figure 21). The modification of the basic cell allows the spatial modification coordinated by the laws of instance.
5.5.5 Kaleidoscopic space (II-b)

This exercise is similar to the previous one, except that pieces instead of being transformed, are moved or rotated applying X-form (Figure 22).

5.5.6 Kaleidoscopic space (III)

This last evolution starts out from a pattern simplification, as regards three dimensional geometry, taking these elements to a cubic state. The space is presented as a limited repetition of cubes, which start growing according to their three growing possibilities (X, Y and Z axes) (Figure 23). This exercise is considered a design exercise in the widest sense of the word. Students can make design decisions in relation to the required space, staying within the frame of certain laws (design premises), which they cannot overlook. Also we can develop this exercise making a chaotic cell, using X-form etc. The variations extend ad infinitum.
6. Conclusion

Digital media contribute in enrich the design process, providing new ideas and possibilities, making it possible for the designer to experience his design as he creates it. And this advantage is magnified as from the recognition of the built-in biases of the new tools. An exhaustive study, intended to identify, recognize and use these built-in biases is necessary in order that the digital media correctly work within the design processes. The fact that the media interaction paradigm is not thoroughly spread among the educational world, that it is often resisted or simply ignored, makes it necessary to search the pedagogic field for a way to make for this lack. It is indispensable to continually develop new practice and teaching resources. Methodologies or procedures made by means of analogical media do not produce the same results when translated to digital media. A design process made with digital media generates absolutely different objects, modified and enriched by the digital media built-in biases.

Applying the series of exercises we propose in this work, during the first year of the architecture career, for five years, we have observed the following:

- Students participating in these workshops are very interested in high quality spatial research.
- The problem of 3D imagination is tackled in a simple way: the “game” of creating complex spaces ruled by simple laws. Playing this game, students can also understand that high complexity is a design variables superposition system.
- Recognizing the built-in design biases in the different architectural representation software, students assimilate the use of digital media as any other, naturally interacting with both, and encouraging the ability of discriminating what media to use according to the design object.
- By means of this kind of exercises, the three-dimensional imagination is rapidly acquired. Constant practice and development of “architectural experiences” [16] helps forming a 3D consciousness, in which students fend for themselves at ease.
- Students also learn how to use the different representation software. Immediate learning and practicing the different drawing commands and orders with the purpose of designing an object, makes it possible to apprehend and integrate the method far more effectively than taking a course on each one of the programs.
- The motivating way in which students face each exercise, as if it was a game, makes the digital tool appear friendlier. Many of them expressed, at the end of the course, that before starting they used to reject digital media, and attributed their overcoming that rejection to the practice of these exercises.
• The autonomy in the process of learning the different software was highly effective. Students explored each one of the commands of the representation software at ease. In spite of having been given a small amount of information, they were motivated to go on exploring.

With this manuscript we intended to be a starting point for the search of underlying ideas which may enrich the design process. By any means we intended the paper to be compendium of digital media built-in biases, but we attempted to lay the foundations for researchers and teachers in this area to construct their own methodologies in order to increasingly integrate digital media to the design process, reinforcing the media interaction paradigm, which is bringing about the great change that today's Architecture projects into the future.

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17. Architecture Schools surveyed:
   Argentina: Universidad de Mendoza, Universidad Blas Pascal, Universidad Católica de Córdoba, Universidad Nacional de Córdoba, Universidad Nacional de Mar del Plata, Universidad Nacional de Rosario, Universidad Nacional de Buenos Aires, Universidad de Flores, Universidad de Belgrano, Universidad de Monu, Universidad del Salvador, Universidad Nacional de La Plata, Universidad John Kennedy, Universidad Católica de Salta, Universidad Católica de Santa Fe, Universidad Nacional del Nordeste, Universidad Abierta Interamericana, Universidad de Palermo, Universidad Nacional de Turquan, Universidad Nacional del Litoral, Universidad de Concepción del Uruguay, Universidad Nacional de San Juan.
   Chile: Universidad Arturo Prat, Universidad Austral de Chile, Universidad de Chile, Universidad de La Serena, Universidad de Santiago de Chile, Universidad de Valparaíso, Universidad del Bío Bío.
   México: Benemérita Universidad Autónoma de Puebla, Instituto de Estudios Superiores de Tamasuipas, Instituto Tecnológico Acapulco, Instituto Tecnológico Campeche, Instituto Tecnológico La Paz, Instituto Tecnológico Los Mochis, Universidad Nacional Autónoma de México, Universidad Tecnológica de México, Universidad LaSalle, Universidad del Tepayac, Universidad de las Américas Puebla, Universidad de Colima, Universidad Autónoma Metropolitana, Universidad Autónoma de La Laguna.
   Perú: Universidad Nacional de San Agustín, Universidad Nacional de Ingeniería.
   Venezuela: Universidad de Los Andes – Mérida, Universidad Simón Bolívar.