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DESIGN GRAMMARS AS EVALUATION TOOLS IN THE FIRST YEAR STUDIO

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SUMMARY: *This paper describes a teaching experience conducted and carried out as part of the coursework of first year students. The workshop is the third of three workshops planned to take place during the course of the first year studio, aimed at introducing new ways of thinking and introducing students to a new pattern of architectural education. The experiment was planned under the theme of "Evaluation" during the final stage. A grammatical approach was chosen to deliver the methodology in the design studio, based on shape grammars.*

KEYWORDS: *Shape grammars, Pedagogical grammars, Design education*

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1. INTRODUCTION

1.1 At the beginning: Design education and reasoning

From the beginning of the year, design instructors are confounded with the prospect of introducing the novices' minds to this extremely different pattern of education, in which they are asked to target complex design problems differently and not in the very direct way they have learned prior to entering design schools (Kucker and Perkins, 2005). Design students as well find themselves required to respond to problems and act on a belief of comprehending the act of creation. They are also expected to simultaneously develop, communicate and proceed to final proposals. While they find it difficult to accommodate intellectually from the beginning to vagueness and indeterminacy of the design process (Heintz and Dougan, 2008, Heintz, 2005).

Researchers in the design education field were motivated by this dilemma. Design tutors, uncomfortable with traditional, experiential, trial and error studio teaching traditions, fell short of being able to effectively transmit a comprehensive codex of design knowledge. Instead, they were searching for more procedural knowledge about how to design and how to reason about designing. The very goal of the new search has been simply to predict the unpredictability of design (Pantazi, 2008).

In studying human thinking and reasoning, researchers concluded that there are two main reasoning systems: one is based on similarity while the other is a rule-based one. The former is an example-based inductive reasoning that pertains to figurative qualities and is therefore largely visual (e.g. thinking in pictures). The rule-based system, on the other hand is a deductive reasoning system that signifies the ability to form abstract concepts and use symbolic representation, primarily through the use of language (e.g. thinking in words).

Gentner and Medina (1998) assume that both reasoning systems are important to the process of learning and that the two cognitive systems occur in parallel during problem solving processes, either separately or interactively. It was also understood by Goldschmidt (2001) later that the strength of activation of one over the other system of reasoning more often is context dependent.

The most important thing about these reasoning systems ,from the design education perspective, is how they helped formulating two important categories of design methods: precedent (case-based) and rule-based design methods (Kalay, 2004). These methods were mainly adopted computationally in developing algorithmic design models, yet each remained of potential to be pedagogically applied in the design studio. Both methods are considered suitable for inducing the fresh minds to design in a well defined manner (Ibrahim et al., 2010) and this is assumed to be based upon the characteristics and process of every reasoning design method.

The rule-based methods, for example, are from the oldest recorded design methods that Kalay (2004) dates it back to Vitruvius's *De architectura* (known as his "Ten Books on Architecture"). They are popular due to their characteristic of capturing explicit processes, providing methods to instruct (and learn) how to complete a task, and therefore widely used in constructing computer programs to solve well defined problems (Pantazi, 2008). On the other hand, in precedent-based methods, past experiences are encapsulated in the form of "cases" of rich, validated and already made solutions to complex problems (Kalay, 2004). This is very similar to the common implicit behaviour of designing and expertise in retrieving and recalling experiences from memory to be modified according to the new specific needs or other variables during the design process.

1.2 Precedent- or rule-based educational model?

Since design is pedagogically seen as a process of solving ill-structured problems, it comes as no surprise that the design education research community is interested more in precedent-based design methods. This could be seen as way to help advanced students to better abstract concepts and to fully exploit their capacity to retrieve and implement previously acquired knowledge.

One of the main obstacles in teaching beginners is the amount of preconceptions they hold, the mindsets and pre-judgments that are mostly—if not all—- illusive and not true about design. This means that part of the problem is located in their previously acquired knowledge, so they are either thought to hold misleading information or are mainly empty minds and reservoirs for new ones (at the very ambitious stage). It is therefore understandable that developing students' ability to recall and process their "design" knowledge might be much easier if it took take place after overcoming their lack of expertise problem (Temple, 2009).

Building up the students' knowledge base process is thus suggested to be handled on two levels with both reasoning operations:

- In non-studio programs:

  A pop-up (bottom-up) cognitive system of reasoning that corresponds to similarity-based (precedent-based) ones. This could be achieved by exposing students to specifically tailored cases of design (Kalay, 2004) to expand their visual experience and provide them at the same time with the base knowledge on which they will draw in further academic years. This will be harvested later in more advanced studio levels, by teaching students the use of prototypes, precedents, analogies and metaphors in solving design problems with similarity-based reasoning methods, thus providing them with a starting point from which to develop new designs.

- Within the design studio:

  Implementing a top-down instructive cognitive system of reasoning in the design studio that may correspond (roughly) to rule-based systems will help lead students during their design work to the process of designing in a concise and stepwise manner. According to the special nature of design problems, the implemented methods should be redrafted to ensure that they remain open (less defined), as will be discussed in more detail in section 3.4

This research adopts a rule based reasoning approach in carrying out its strategies within the first year design studio. The implemented methodology is loosely based on the concept of grammatical design and shape grammars. The potential of implementing such methodology will be explored by investigating its concept, mechanism, and pedagogical applications as well as evaluating the possibilities of applying such methodology in the first year studio structure.

2. SHAPE GRAMMARS IN THE FIRST YEAR DESIGN STUDIO

"Anyone learning how to paint, write music, poetry or skills of architecture will inevitably find that the learning of recipes, principles, rules of thumb and more exact rules for achieving varieties of effects and results, will be just as prevalent as in any 'less exalted' trade or profession"

(Harrison, 1978) cited by (Bruton and Radford, 2003)

In art and architecture, the grammars concept draws on analogies between visual and natural language. The use of "grammar" and "language" as metaphors in design (especially architecture) is an attempt to make seemingly tacit practice explicit through defined criteria (Bruton and Radford, 2003).The term "grammar" captures a sense of order in matter and form. It is therefore familiar beside other terms like "style" & "theme" that highlight the awareness of form repetitive patterns, constituent parts, compositional rules and families of designs that share common features.

2.1 Shape grammars in design education

Supported by its success in analysing and synthesizing design, shape grammar has been brought into design education in various forms. In many instances it has been introduced as a generative design methodology during design computation classes, and in other occasions it has been highlighted as a design methodology in specific design projects through design studio work.

To get a deeper insight into shape grammar's implementations in design education, its previous pedagogical examples have been carefully investigated to define some of its possible models (scenarios) of application, whether in studio or in design computation.

The analytical study has been carried out throughout different factors that later facilitated the study and the comparative description of all models. In addition to the pedagogical milieu (design studio/design computation) of the application, aspects like the implemented process, the students' participation and the grammar's type and context were taken into consideration when describing each model.

Tutor	Terry Knight	Terry Knight	Julie Eizenberg	Economu	Ulrich Fleming	Ahmad & Chase	Andrew Li	Birgul Colakoglu	Miquel Prats	Gabriela Celani & others	Kotspoulos
Institute	UCLA	MIT	Several	Georgia Tech	Carnegie Mellon	Strathclyde University	Chinese University of Hong Kong	Yildiz Technical University	EUDI	UNICAMP	MIT
Grammar [Reference]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Application environment	DS	DC	DS	DS	DS	DC	DS	DC	DS	DS	DC
Students (N/ A)	A`	A	A	A	A	A	A	A	A	A	A
Type of grammar	S	A	A	S	A	A	A	A	A	A	A
Simple / Extended	E	S	E	E	E	E	S	S	E	E	S
2D/3D	3D	2D	3D	3D	3D	2D	2D	3D	2D	3D	3D
Rules development responsible	Student	Student	Student	Student	External	External	External	External	External	External	External
Scenario type	2e	2	2e	2e	1e	1e	1	1	1e	1e	
Type description [S / FS/ SP]	-	S	S	-	FS	S	S	S	S	S	
Design context	Personal preferences	Brand design	Architect style	Personal preferences	Traditional architecture	Brand design	Traditional architecture	Traditional architecture	Pattern design	Architect style	
Notes											

Application environment: (DS) design studio /(DC) Design course pedagogical applications of grammar took place within:
1. Design computation courses as an exercise thus development and application was an evaluation of the student's understanding and ability to work (extract , apply and modify) with grammars .
2. Design studio environment: to aid developing certain skills in students during the design/ grammar process.

Students: The target group of students , either (N/ Novice) or (A/Advanced)

Type of grammar: (A) Analytical / (S) Synthesis

Type Description: According to Habraken, there are at least three ways of seeing the same type :
(S) a stylistic system
(FS) a functional /spatial system
(SP) a structural /Physical system.

Design context : the context of the design examples upon which the grammar's rules are based

[1]	UCLA students work with various design projects	(Knight, 2001)
[2]	BMW grammars & Bettle grammars , MIT students	(Chin, 2004)
[3]	Not specified , mentioned in	(Knight, 1999)
[4]	New Opera House at Oslo	(Economou, 2000)
[5]	Wall grammars and others	(, Heintz, 2005Flemming, 1990)
[6]	Greek Temple Grammars	(Ahmad and Chase, 2007)
[7]	Yingzao Fashi Grammars	(Li, 2001)
[8]	Houses design	(Colakoglu, 2007)
[9]	Pattern Grammars	(McKay et al., 2009)
[10]	Modification of Wright's grammars	(Pupo et al., 2007)
[11]	HFH Housing Grammars	(Kotsopoulos and Liew, 2004)

FIG 1: a comparative study of shape grammars pedagogical applications(Ibrahim, 2011)

2.2 Implementing grammars in the first year design studio?

FIG 1 reveals that most (if not all) of the targeted design students are on advanced levels (graduates, post graduates), rather than beginners. This observation has been made with the available information about shape grammars' pedagogical applications, whether in the design studio or computational courses. This can be explained as a logical consequence for several reasons; most of them are about the exceptional nature of both shape grammars and the beginners' acquired knowledge. The investigation of the following aspects may uncover some of the main causes that lessened the possibilities of applying shape grammars in the First year design studio:

- The analytical skills:

  To develop analytic grammars means to be able to extract common features of a wide range of designs, a very critical and systematic process of comparison and analysis that should at the end reveal the hidden variety of common vocabularies, details of conditioned or non-conditioned rules, as well as their sequence of application. Such analytical skill is thought to be less developed in novices than in graduates or post graduate students; it is logical therefore to find more cases addressed to students on advanced levels based on their already developed analytical skills in this area.

- The knowledge repository (expertise):

  As synthetic grammar depends on the selection of vocabularies and rules that promise to solve certain design problems, the selection lays on the designer's experience, his knowledge repository and more on the level of "expertise" accumulatively acquired and developed during the solution of similar problems in education and practice.
  Developing this kind of expertise is one of the main aims of the architectural studio, especially on the undergraduate level; this development is normally planned to occur over a comparably extended period of time. It is easier for advanced students to begin experimenting with grammatical designs at the final year, and is thus too early for the beginners to build their synthetic grammar implementations upon their limited and insufficient level of expertise.

- The algorithm:

  Shape grammar is one of the CAAD tools developed with computational potential in mind. To employ grammars, students should be provided with another kind of education, an algorithmic

(mathematical) education that promises to help them understand the symbolic description behind the theory's mechanism and master it. It is therefore difficult and more complicated to introduce this type of exercise to beginners before acquiring this kind of education first at the introductory level of the design studio.

Despite these facts, and although there is no comprehensive literature on the use of grammar systems for the beginning design studio education, the methodology is thought to be well-suited for teaching beginners:

- Firstly, the grammar's concept is mainly about "making tacit knowledge explicit" (Pantazi, 2008). A pedagogical grammar therefore could benefit from manifesting this implicit knowledge in a more explicit way.
- The grammar development and application stages expose some of the main design strategies, principles and even simple compositional operations. The implicit teaching of these issues makes the methodology more relevant for teaching beginners composition and visual correlation (Knight, 1999, Economou, 2000).
- To some extent, shape grammars' scenarios (FIG 2) (especially the extended synthetic grammars process) capture the layout of the design process (FIG 3) and adjust students to it. The operations of cognition, production and evaluation are embedded in these scenarios in a way that promises beginners development of a good understanding of and control over their own design processes.

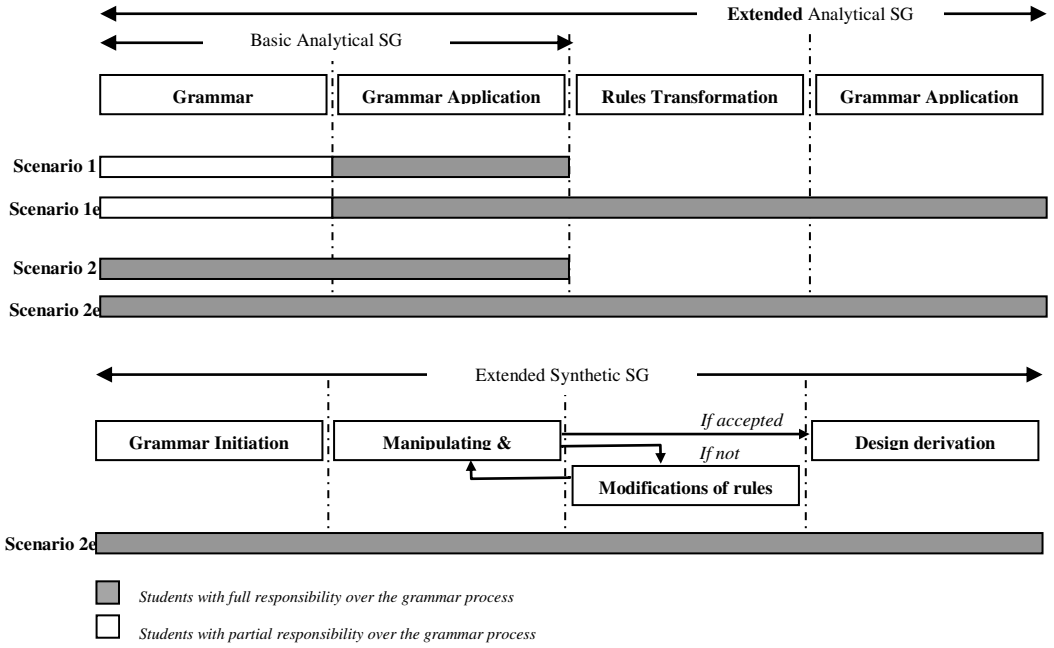

FIG 2: Possible scenarios for pedagogical analytical and synthetic grammars.(Ibrahim, 2011)

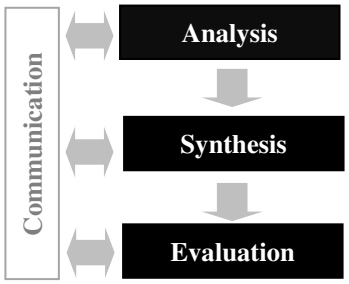

FIG 3: Kalay's major components of the architectural design process.(Kalay, 2004)

- The methodology is also very significant to be used in the studio's project based approach, as the implementation stage of synthetic shape grammars involves a playful "making" process. This can be clearly seen in some early examples like Fleming's wall grammar (Flemming, 1990). Other examples such as Knight's work with UCLA students (Knight, 1999) show the power of this simple mechanism to inspire students producing large and complex designs in their studio experimentations.

Design, as discussed earlier, is not a well-understood process (Kalay, 2004). As it proceeds, changes occur and designers sometimes need to use the same elements in different relationships, introduce new elements in existing relationships, or even changing the relationships. Encapsulating this process in deterministic rules is, at the very least, very ambitious: "descriptions fix things in computations and nothing is ever more than its description anticipates explicitly" (Stiny, 1994). To apply the grammar in the beginning studio structure, its deterministic, strict and unequivocal nature is the main aspect of the methodology to be reconsidered in every stage of the structure's model. It is also relevant to keep the process open (as for the ill-structured problems); the applied model should guarantee some degree of flexibility in its vocabularies and rules' descriptions to allow all these reinterpretation and changing situations to occur.

Moreover, the studio grammars do not need to be computationally processed or developed: the decisions are manually explored. The notion of design in shape grammars is implemented in a broad sense, encompassing the more general aspect with the narrow, computational one. As a result, part of the process depends on the student's intuition; together with the flexible vocabulary and rules, this will reveal more meaningful varieties during and at the end of the design process.

It is also believed that any set of rules necessarily encapsulates its author's views, biases, and convictions, without allowing any room for argumentation or dissent (Kalay, 2004). Using such a methodology with novices will be like replacing their own preconceptions with new ones. To avoid that, rules need to be more general and students should gradually take more control of them during their experimentations, giving more space for experimentation and personal creativity.

3. THE GRAMMATICAL AND PEDAGOGICAL MODEL

3.1 Three stages: Three workshops

The presented work is based on a pedagogical model of the beginning studio (Ibrahim et al., 2010) that structured the first year studio and divided it into three stages: recognition, production then evaluation (figure 4).

FIG 4: The three stages of the beginning design studio (Ibrahim et al., 2010).

Three experiments were scheduled to take place accordingly over the course of each stage in order to evaluate the effectiveness of the framework in delivering the planned learning outcomes for each stage. The work was carried out in the first year architectural design studio at Strathclyde University.

The early stage experiments were crafted with a main goal of nurturing the skill of seeing; with more creative and ill-defined design tasks (Ibrahim et al., 2010), the mid stage ones utilized formal strategies to help students designing with constraints (Ibrahim et al., 2011); while the final stage's tasks aimed at creating connections, testing the understanding, harvesting the fruits of the whole year's efforts in the most architectural-like experience of the year.

3.2 Final stage: evaluation

Evaluation is not an intuitive process; it is a rational in which students sway back and forth between testing and questioning, using both non-empirical data and intuition in creating and executing. Beginners then are engaging in judgment that is followed by careful and numerously repeated analysis. The results of the evaluation are communicated back to the recognition and production steps for improvement or adjustment of the solution, or for changing the requirements.

The main objective of the evaluation is for students to take more responsibility for their personal decisions; an important component of it is self-criticism (Farivarsadri, 2001). The student should be able to criticize his/her own work as well as the works of the others, and to share his/her ideas with them.

3.3 The Applied SG Model

Experiencing architecture at this stage means to develop what could be seen as the students' most comprehensive design experimentation of the year; it gives them ownership and opportunities to make meaning for themselves in their projects. Allowing students to take full responsibility for their project is one way to encourage depth and thorough, elaborative processing of information. This also confines the possibilities of the implemented grammatical models between the analytical and synthetic scenarios (FIG 5).

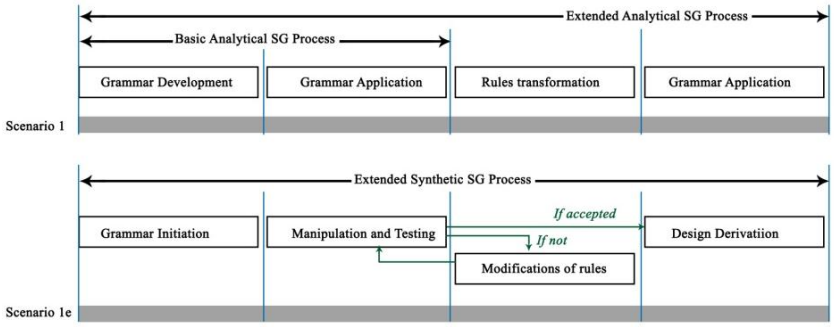

FIG 5: the suggested SG models for the final stage

3.4 Evaluating the "evaluation" stage

Generally in the beginning studio projects, the students' design process is seen as important as their end product. But in evaluating the final stage's success, the steps taken from the beginning of the process until the end are more important (Utaberta et al., 2010; s Seymour, 2008).

Chances for monitoring the students' progress are greater for the final stage's projects as the allocated time is probably enough and consequently more focus is given to the design process. Firstly, the focus is given to the evaluation of their self-learning process, the way in which they have benefited from precedents, their previous experimentations and the instruction they have received throughout the year. Secondly, the evaluation of the evaluation of their self-criticism, the rationale behind their decisions, the logic they based their evaluation on, the pedagogical outcome of Rolheiser and Ross's stages(2001), and most importantly, the way they did respond to it in the transformation of design and the generation of alternatives.

4. THE EXPERIMENT: *"DOING IT HIS WAY"* (DESIGN LANGUAGE)

Beginning students were introduced to the idea of design languages from the grammars' point of view, believing that great artists and designers are distinguished by the regularity of their approach or the qualities of their output. "The quality of consistency" (Bruton, 2008) seems to be a structural fundamental for good design. They were required to develop their own grammatical tools, the set of strategies offered for reconsidering the process of design thinking. The tool includes use of metaphors of grammar that frame the design process in terms of core structural components. These components are the fundamental conceptual tools that offer alternatives strategies for design.

4.1 The workshop

Rather than allowing students to analyze work found in books or online resources, they were required to analyze their own work, to develop consciousness about their own languages, process and design elements in an extended grammatical process that consists of all stages of Analysis->Design->Transformation->Design.

Days before the workshop, Strathclyde first year students were asked to bring their design portfolio that contains the whole year's studio work. The tutorial began with examples from architectural and artistic styles showing the resemblance between designs from the same language. The linguistic interpretation of design was then introduced in terms of vocabularies, rules and derivation.

A group of around thirty volunteers was selected to proceed with the workshop's experiment in groups of twos:

Firstly, each was asked to analyze his/her work, find regularities and extract his/her own language. In this step they had to script their design logic whether graphically or in words.

Secondly, each had to exchange his/her language with his/her design partner and according to the new language design a space for meditation. Students had to communicate and express this language in a clear way so as to help his/her friend in understanding and using it.

The third step was to criticize and evaluate the design language in hand and make needed modifications to the vocabularies, rules or both. The final stage was to redesign the meditation space using the transformed language.

5. OBSERVATIONS

Being dependent on the whole year's teaching, this stage's outcomes were mainly influenced by the studio curriculum. The students' response, their structured analysis and reflections were not only affected by their intuition; the accumulated knowledge and the teachings of the project-based studio affected the maturity and depth of their studio practice.

5.1 Extracting the vocabulary

Students were required to formulate the consistency of their design approach, so they varied in their ways of expressing the language using narrative or graphical presentation or a mix of both of them. What is more important was that their efforts revolved mainly around two different models for the language extraction:

One is simply a guide for the general (and sometimes specific) design preferences embedded in their project, described as a like and dislike list of strategies, design aspects, geometrical forms, etc. FIG 6 and 7 show a written and graphical example of the preferences language.

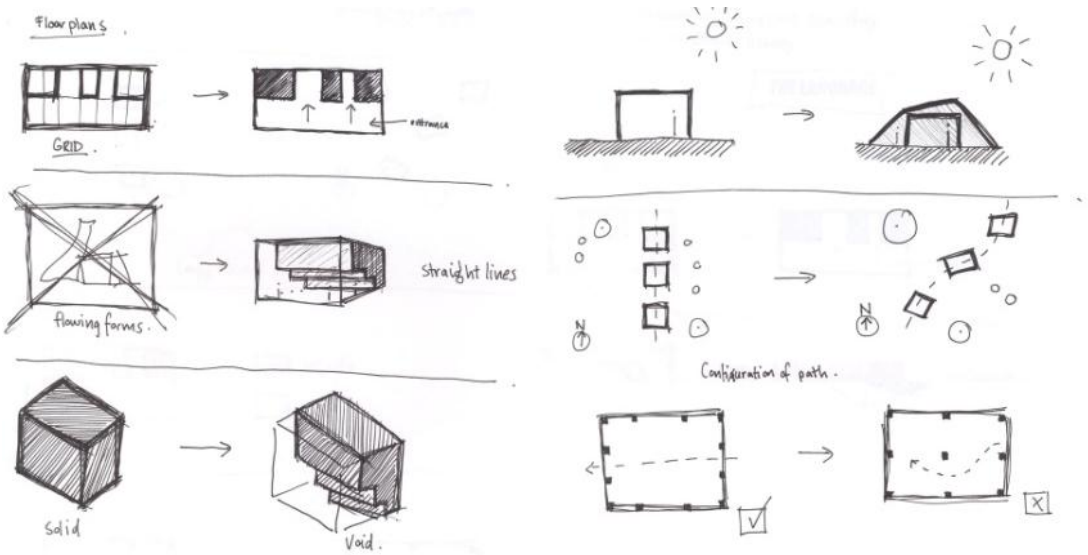

FIG 6: a graphical presentation of the design language in the form of like and dislike design preferences (Student: Jonathan Dawson-Bowman)

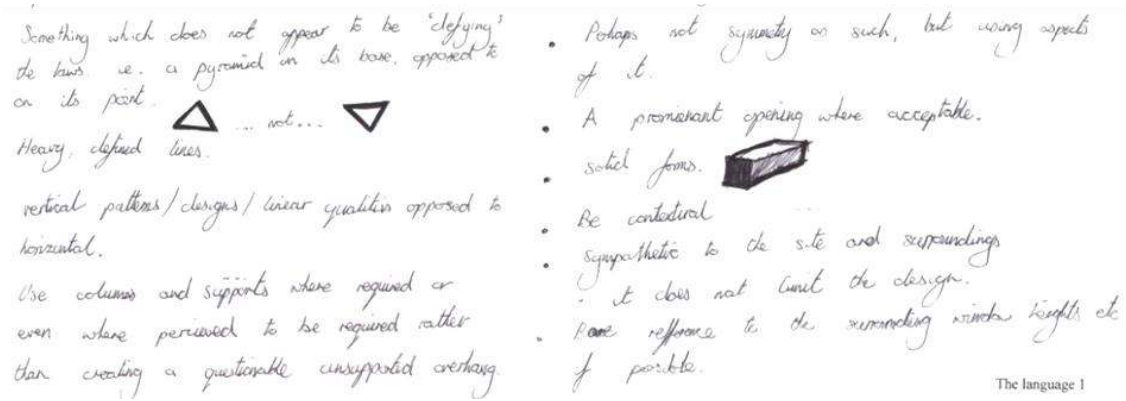

FIG 7:An example of a written language of preferences (Student: Christine Halliday)

The other model resembles the rule based models, offering step by step recipes for their formal or conceptual design process.

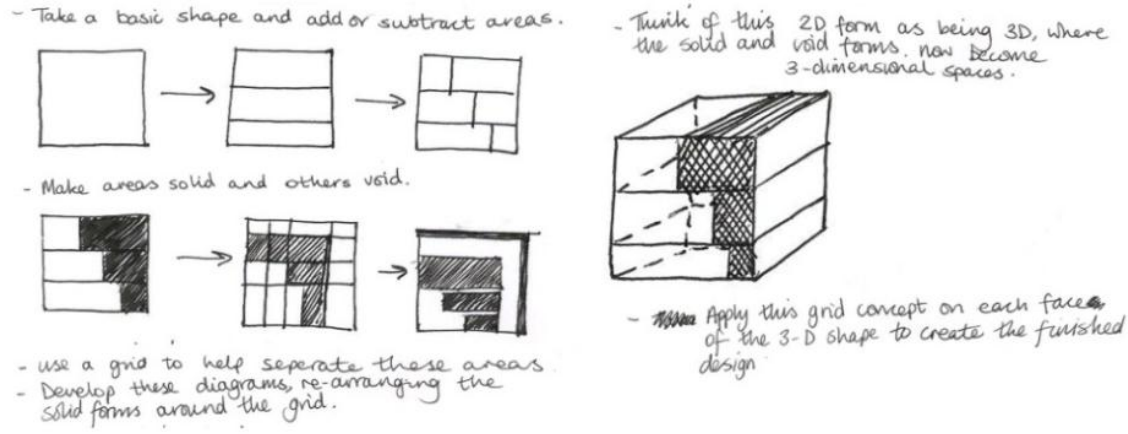

FIG 8: a rule-based description of the language influenced by the subdivision grammar of the "How to do it?" workshop (Student: Claire)

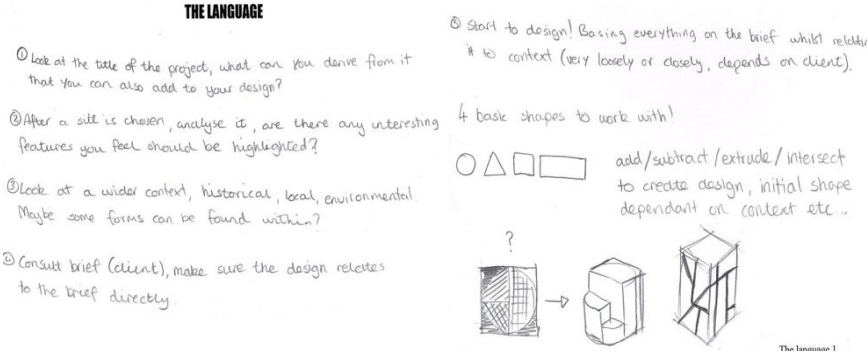

FIG 9: Another step-by-step guide for creating designs under the same language (Student: Simon McGreachan)

FIG 9 show other examples of a design language that expresses in words the process of designing according to the student's work.

5.2 Applying the other's language

The difficulties associated with this step are not only concerning the application of the others' languages; once handed their peer's language, the first challenge for the beginners is in turning the written words into graphical

presentation, something that they flawlessly did in the workshop and is believed to be due to the qualitative and quantitative use of narrative in the beginning design studio. They read, understand and reflect graphically upon what they have read; They are good recipients of knowledge on a hand, and on the other, they really know how to communicate their ideas (FIG 10).

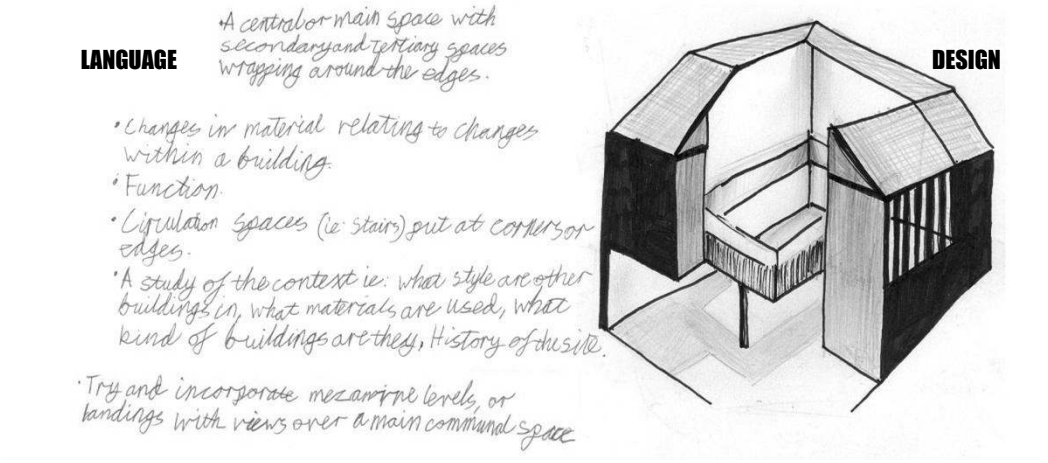

FIG 10: Turning narrative into graphical presentation (Language: Andrew Clark, Design: Jonathan Dawson-Bowman)

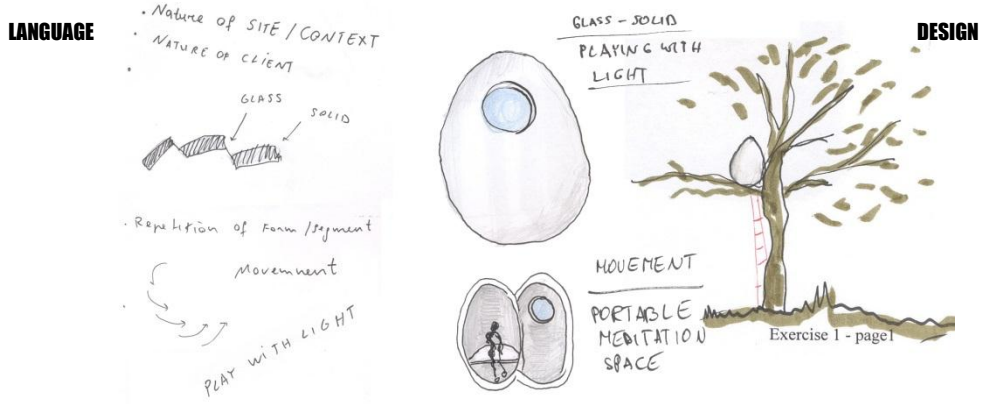

FIG 11: Following her friend's language, Paulina managed to create something special with some general rules (Language: Laura Petruskeviciute, Design: Paulina Narusevicuite)

The second challenge was in following and respecting the language while trying to create something differently—innovative perhaps—at the same time. In response to this, some stuck to basic application of the rules, while others managed to simultaneously find intuitive ways of escaping the strictness of the rules in the application and be creative (FIG 11).

5.3 Evaluating and transforming the language

Transformation was the new key operation in this final stage; the rationale behind the language evaluation and modification was analyzed in the light of the students' work. What could be drawn from the results is that students apparently based their language transformation decisions on one of the following three methods:

Experimenting: is a curious act of changing or substituting some of the initial shapes or steps of application with others. This is done for the purpose of exploring the implications of such change on the generated designs as well as on the design derivation process. In FIG 12, for example, the student changed the configuration of the shape multiplication and substituted the L shape arrangement of squares with an S one in two subsequent steps of his friend's language

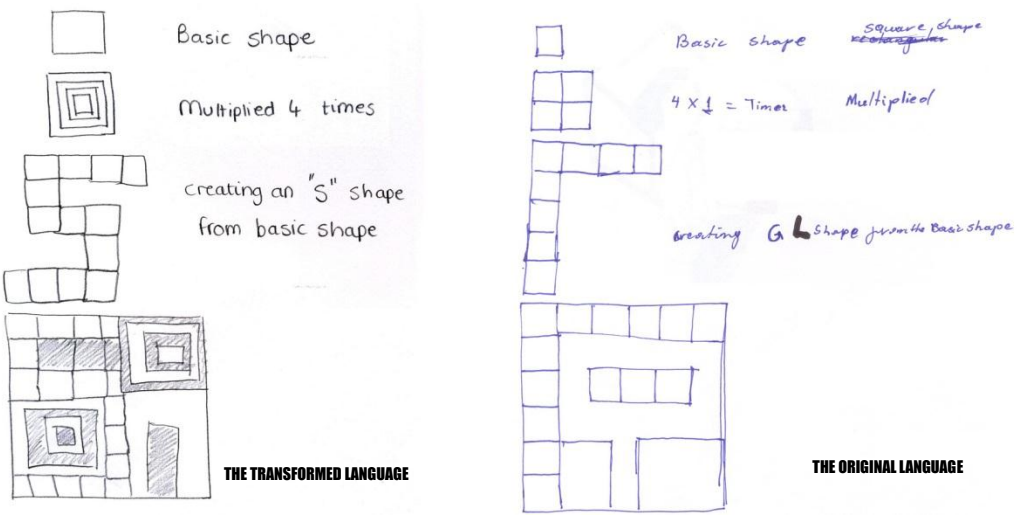

FIG 12: Experimenting with changing and substituting some of the language rules (Original language: Ilir Doci, Transformed language: Jennifer Rooney)

Another transformation (FIG 13) intended to extend the language's formal strategy, incorporating several strategies (addition, extrusion and intersection) alongside its original subdivision one.

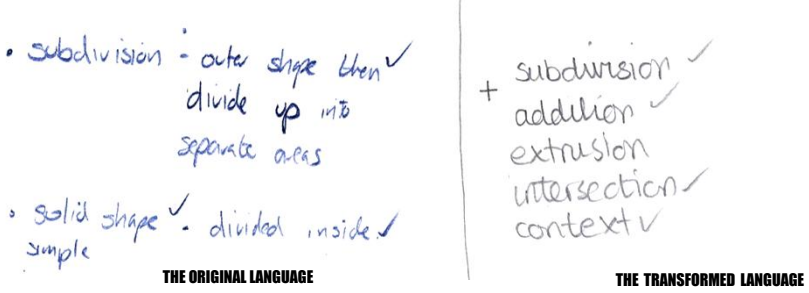

FIG 13: Experimenting by the addition of the three strategies of addition, extrusion and intersection with the subdivision's one (Original language: Simon McGreachan, Transformed language: Ian Duthie)

Rationalizing: is a process in which all design modifications were based on a thoughtful and rational evaluation of the original language's choice of elements and rules. This means that the decision of accepting or rejecting the language (or part of it) is not taken upon personal preferences; it is only built on a logical basis. This debate creates a kind of interesting conversation between both students' languages (the original and the modified) (FIG 14 FIG 15).

FIG 14: An example for the logical modification. Laura mentioned that her language involved the formal expression of movement in design, giving an example from her projects, while Paulina questioned this rationale, asking "If it's about movement, why dance space (in an ongoing project) strictly defined?" (Rationale: Laura Petruskeviciute, Criticism: Paulina Narusevicuite)

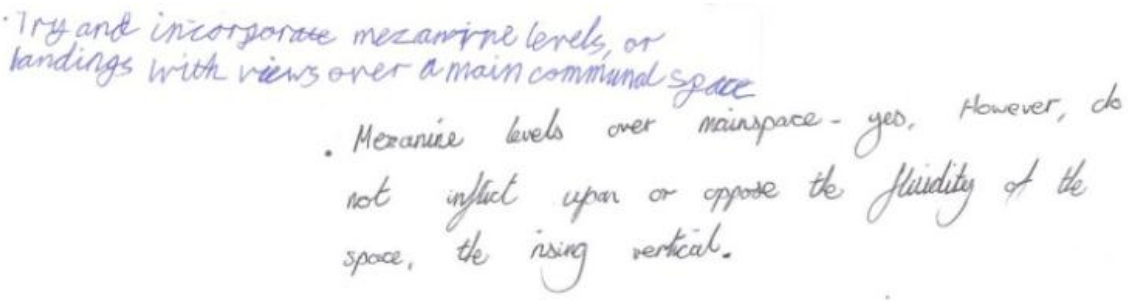

FIG 15: The dialogue of rationale and criticism between another two students (Rationale: Andrew Clark, Criticism: Jonathan Dawson-Bowman)

Personifying: To familiarize themselves with the language and have some flexibility in the design process, some students tried to modify the language so as to blend their own vocabularies/rules with their peers' ones. Creating a mix of both languages that is only based on personal considerations (Fig. 16).

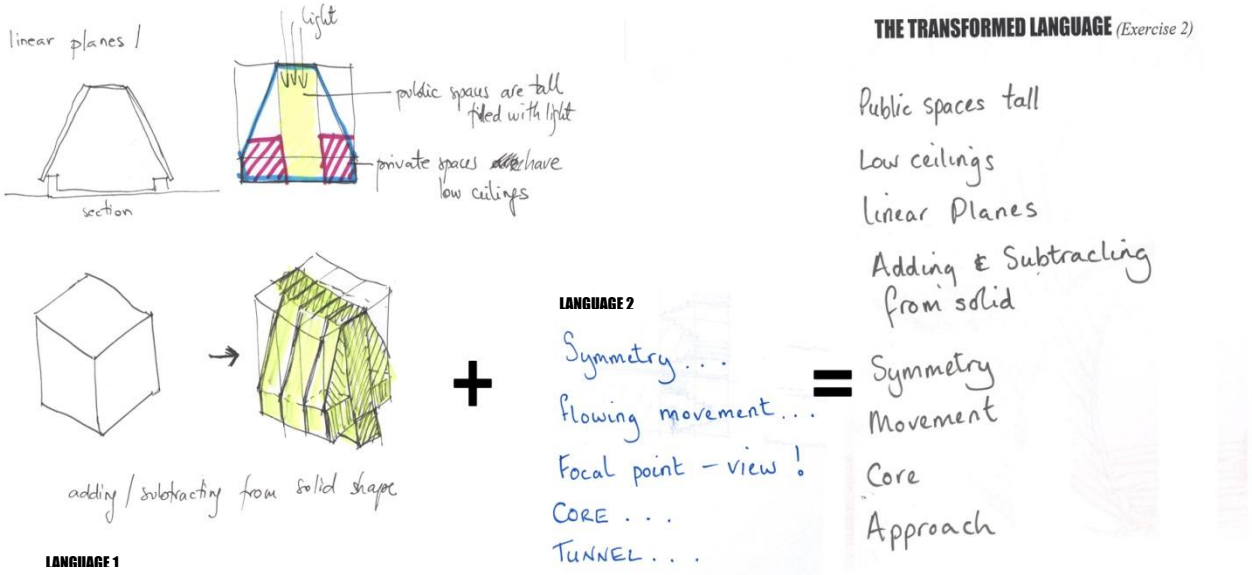

FIG 16: the Mix of two languages in the work of some students (language1: Elena Staicu, Language2: Angela Breton)

6. 4. CONCLUDING REMARKS

The problem-based curriculum of the first year studio provided the students with knowledge and experience that enriched their work with thoughtful and rational experimentations. This also had the effect of facilitating the achievement of the final stage's objectives within the scope of the applied workshop.

One interesting result was that most of the students dealt with the meaning, needs and sense of the space more than its visual appearance. Their conceptual drawings showed more focus on the feelings they wanted to convey for "meditating", delivering this through the use of material, texture, views, light and shades (FIG 17). Again we can attribute this to the well structured problem-based approach of the studio, the openness of the project's theme, the whole year's narrative and the structured evaluation criteria that gave them the idea that design is not only about the beauty of the outer form.

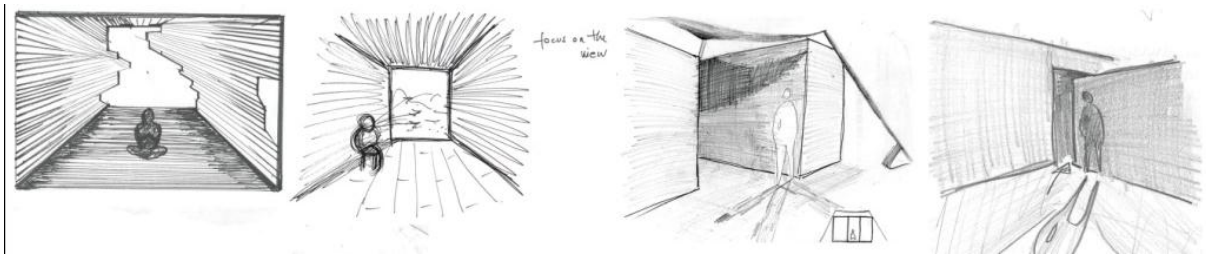

FIG 17: Some of the students' sketches that showed more concern with the configuration of the inner space and its sensational experience

From the feedback session, it has been seen that students feel more productive once they recognize their strengths, and respond to the regularities they discover in their bodies of work through the transparent records provided in their grammatical exploration. They are also more confident because they can see how their work was achieved and hence how similar work can be achieved again, and how changes to the use of rules and vocabulary might alter the work.

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