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Proposal for didactic innovation in the teaching of descriptive geometry

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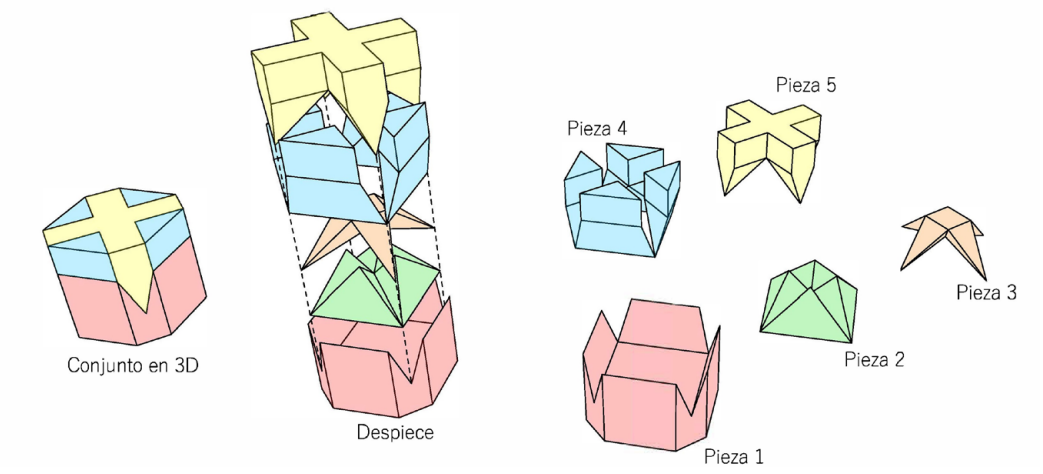
Abstract

The lack of motivation of students in a subject with a high degree of complexity, such as Descriptive Geometry, represents a significant challenge in the educational field. To address this problem, a methodology was implemented that focused on the application of real architectural models with the possibility of getting to know them *in situ*. The model chosen, the Casa de la Música in Arroyo de la Encomienda, provided the students with a tangible and practical perspective of the abstract concepts of Descriptive Geometry. The results obtained revealed a notable increase in the students' understanding of the process of graphic representation, as well as a greater understanding of the importance of Descriptive Geometry in architectural design.
In the conclusions, it was highlighted that the application of new methodologies was well received by the students, showing a significant increase in their motivation. This approach not only gave the students the strength and drive to overcome the challenges of the studio but also allowed them to keep an open mind to explore and approach projects in innovative ways. In summary, the implementation of innovative educational strategies proved to be effective in revitalizing students' interest and improving their academic performance in Descriptive Geometry.

Keywords
descriptive geometry, architecture, teaching innovation, motivation, model.



3D model of the Casa de la Música auditórium. Elaboration of the authors.

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Introduction

Descriptive Geometry is a discipline that studies the graphical representation of two-dimensional surfaces. If we go back to Egyptian times, with the Ahmes papyrus (1650 BC) the geometric methods used for surveying were developed. There are also known representational plans that combine floor plans and elevations in the reliefs of the tomb of Aten (1370 BC). With these representations, a spatial simulation can already be glimpsed, a three-dimensional space that is described in two dimensions [Tordesillas et al. 2022, p. 33]. As time went on, in Greece, geometry developed and became a science. Thales of Miletus (624-546 BC), Pythagoras (570-490 BC) and Euclid (323-283 BC) laid the foundations for the study of geometry in our Western culture.
Nowadays we take the graphic procedures of descriptive geometry that were developed in France by Gaspard Monge (1746-1818). In his Treatise published in 1811, he shows how to represent plans and elevations in two dimensions. He developed what we know today as the Dihedral System [Monge 1811].
The subject in which the method presented here is developed is Descriptive Geometry, as part of the Fundamentals of Architecture degree. It is taught in the first year of the degree, is annual, and has nine ECTS credits. It is an eminently practical subject.

Objectives

Knowing the difficulties the students have in understanding and drawing three-dimensional space through its representation in two dimensions, we want to adapt our teaching methodology by means of a new exercise. There are several objectives:
To motivate students and bring them closer to built architecture, we have proposed a project taking a real model as the object of study. A building near the School of Architecture that has allowed a visit to be made with the architect co-author of the project: Javier Arias.
We want to check whether the use of models in the methodology of teaching geometry can improve the three-dimensional understanding of concepts and promote more active participation of students. To transform the teaching of the dihedral system into a more interactive and meaningful experience, stimulating students' interest and understanding through the creative use of a cut-out that will become a model (figs 1, 2). To help students acquire the skills of spatial vision and formal control so that in higher grades they will be able to design good architecture.

Development and methodology

The teaching of Descriptive Geometry conforms for the most part to the Workshop regime. The teaching method followed is based on a combination of pedagogical techniques. Theoretical explanations (master class) are carried out along with in-class exercises. A couple of exercise books have been published that complement the subject: "Solved exercises in Descriptive Geometry: Dihedral System" [Tordesillas 2014] and Descriptive Geometry: theoretical foundations [Lopez Bragado 2020].
The subject is divided into three thematic blocks, each focused on a different representation system. The first block is the dihedral representation system, in which the basic concepts of this system, the representation of figures, the intersections between figures and the representation of shadows, are taught (fig. 3). The second block is focused on the bounded system, explaining the representation of roofs and terrain grading. The third block is focused on the conical representation system, in which the form of representation, the calculation of shadows and conical rectification are taught (fig. 4).
The methodology proposed in the subject is based on the didactic concept of teaching to reason by thinking spatially and not learning by heart the automatic instrumentations on the plane [Tordesillas 2022, p. 54].

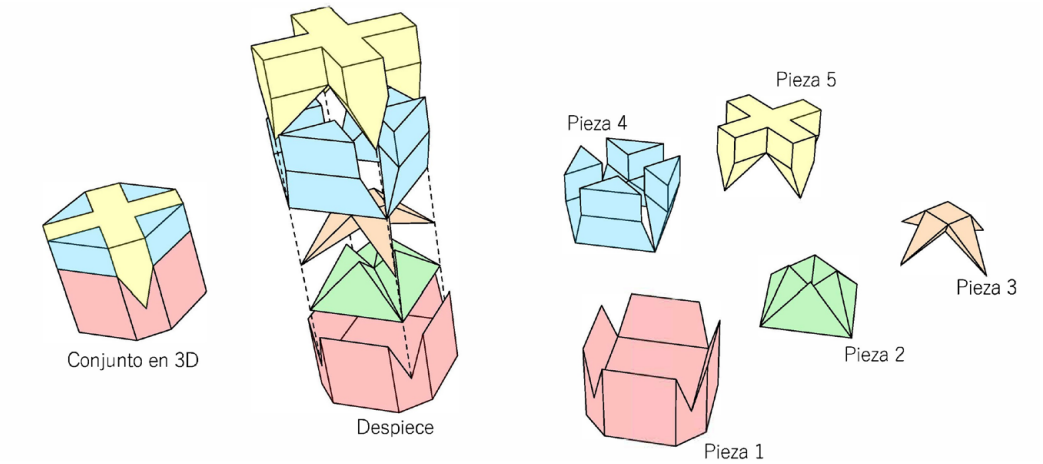

Fig. 1. Semester exercise images. Elaboration of the authors.

To this end, the three-hour weekly classes are organized so that in the first hour, hour and a half, the corresponding theory is explained, and in the remaining time, a practice related to the explained theory is carried out. As the groups are small (15-25 students), it is possible to make a more individualized correction to each student as they develop the exercise and even reason as a group, in a workshop style, about the steps they have to take to achieve the final result. As a complement to the theory and practices carried out in class, complementary exercises are proposed every six months based on existing architectures or objects so that they can apply all the knowledge learned. These exercises are based, for example, on the creation of models from developments or fold-outs made from a single piece, the creation of geometric toys from figures in a dihedral system (fig. 5), or the design of ski resorts applying the bounded system (fig. 6).
The theoretical contents on which the development of the practical case is based are those explained in class. For example, when they are asked to generate a foldout of a building from the floor plan and elevations, they have to apply the methods of collapsing, plane change or rotation to be able to calculate the faces that define the building in true magnitude.

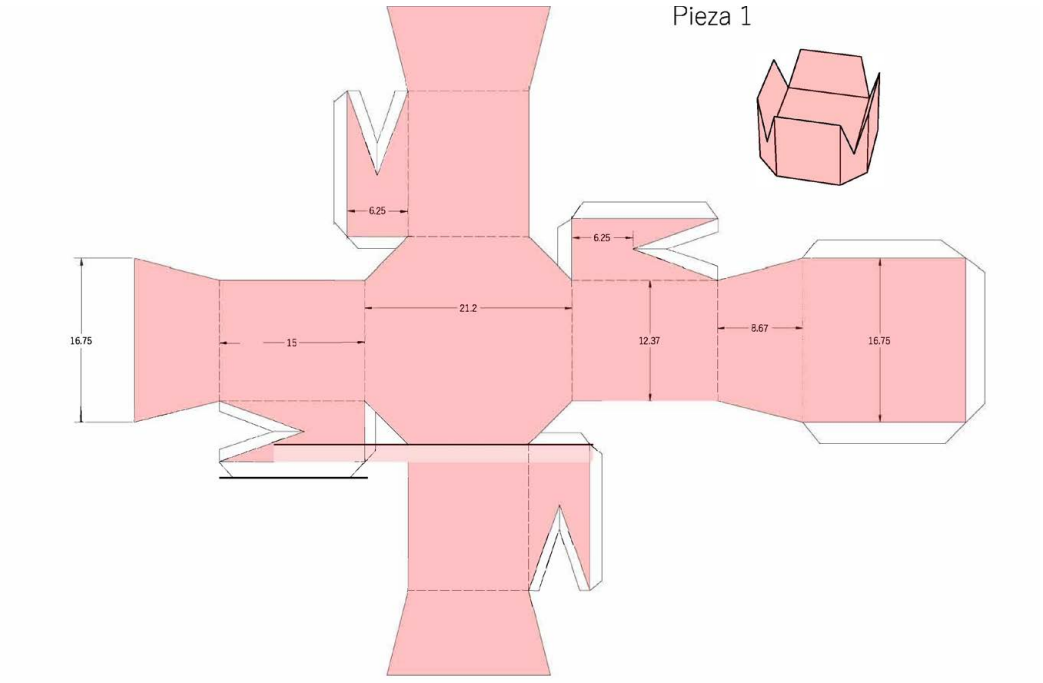

Fig. 2. Semester exercise images. Elaboration of the authors.

In the case of the design of the ski resort, they are provided with the plan with the contours and the basic conditions of the slopes or facilities that must be met, and from there they must analyze the terrain to detect the best slopes and draw their proposals.
In all cases, spatial vision is very important, which is why the use of working models or the use of 3D design tools is essential (figs. 7, 8).
In our case we use SketchUp thanks to its simplicity and ease of use.

Practical case and results

The building above which is proposed to be worked on by the students is a building constructed in the year 2021, whose architects are Arias and Garrido. It is about "the House of Music and the Theatre". It is located in Arroyo de la Encomienda, province of Valladolid.
The building materializes through interconnected autonomous pieces to resolve the program of an auditorium and music school (fig. 9).
Arias Garrido architects comment "The musical metaphor appears in numerous points of the proposal, from the own conception of the rooms as musical notes on a pentagram, passing through the design of some elements and coatings such as railings and parapets, until the insertion of an illustrious melody in some points of the floor." [AA.VV. 2023, pp. 116-121].
For the assignment, the volume of the largest entity has been selected, which corresponds to the auditorium and its related dependencies. This is located to the north of the parcel. The volume of this piece is made up of four totally vertical elevations, which correspond to

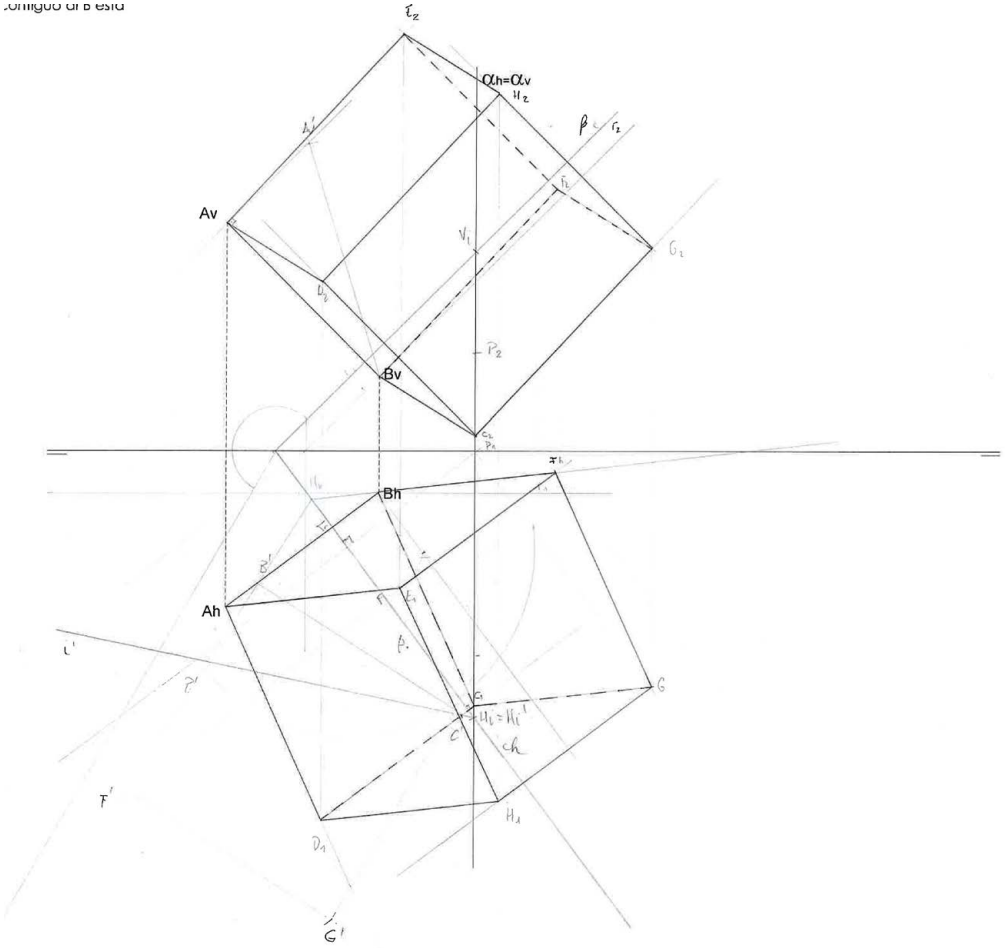

Fig. 3. Example of sheets made by Descriptive Geometry students' dihedral system and conic representation.

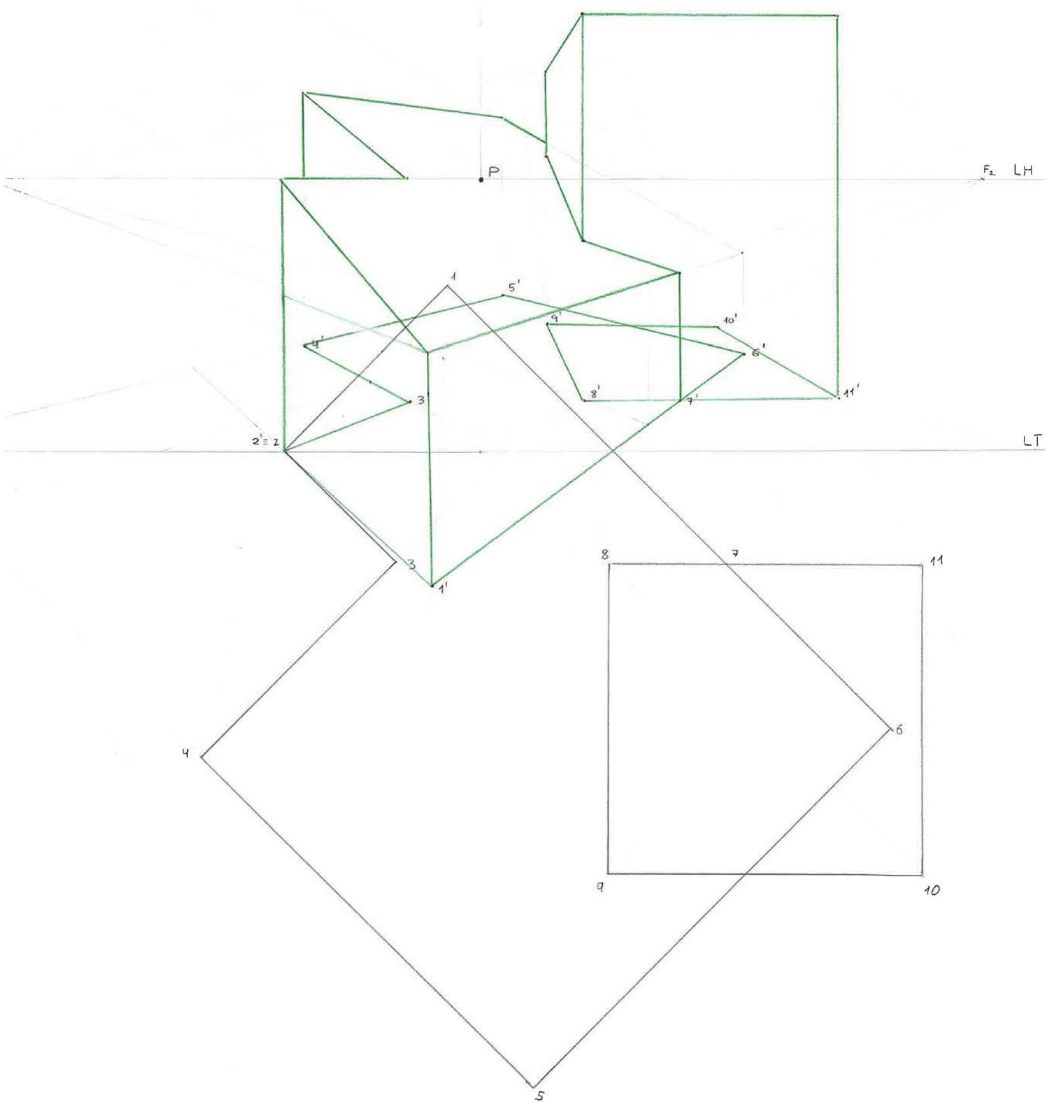

Fig. 4. Example of sheets made by Descriptive Geometry students' dihedral system and conic representation.

a practically rectangular plan, and a cube composed of inclined planes of a triangular shape. I work to create part of a volumetric study of the building starting from its dihedral projections. It is best to build the main auditorium curtain in a single piece starting from the end of your carousel on a white card. If you plan the building in two dimensions, you have to unroll it to fit the three dimensions. The representation in two dimensions through the dihedral system of the characters that make up the volume is more popular, as I was working on in class during the first semester. There is the possibility of carrying out the exercise by hand with a computer. The final delivery must be made in A1 format. It allows the placement of the floor plan and elevations of the building once, creating various simultaneous dihedral systems. The objective of the work is to determine the true magnitude of each of the characters in the volume, which complication is part of the 8 inclined planes that form the cube. In the calculation and representation, it is necessary to ensure that no one piece is discussed above the other. If you will operate with reductions, floor changes or turns in another project of the building, without exceeding, in any case, the five data initially: floor plan of cubicles and four elevations (figs. 10, 11).

In the second part of the exercise, and once you have calculated the true magnitude of your objects, if you more quickly construct a map of the volume of the auditorium (fig. 12), it is clear that you will move from two dimensions to three dimensions.

This template created from the solutions obtained in the first part must be of a single piece. This part of the exercise obliges the student to think about an optimal placement of his objects, studying mountains, valleys and areas for the execution of the task. Likewise, the difficulty added to the exercise arises in the composition of the foil. Thinking about the knowledge learned by the students, they must work towards the result by appropriately placing the exercise procedures. In this way, it is ensured that the solutions drawn up in true magnitude throughout the general process are properly implemented. It is clear that a

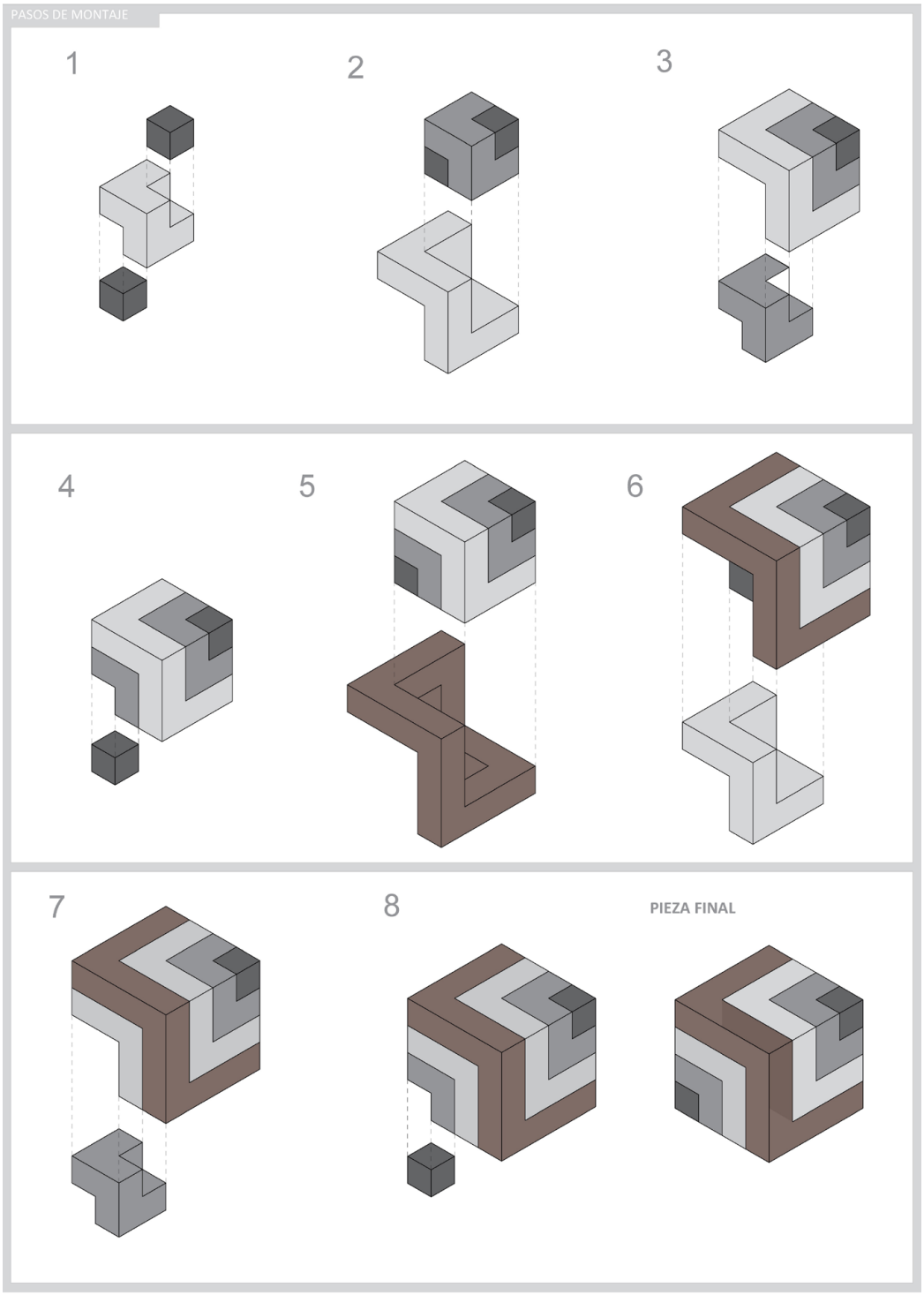

Fig. 5. Examples of some sheets of semester exercises made by the students.

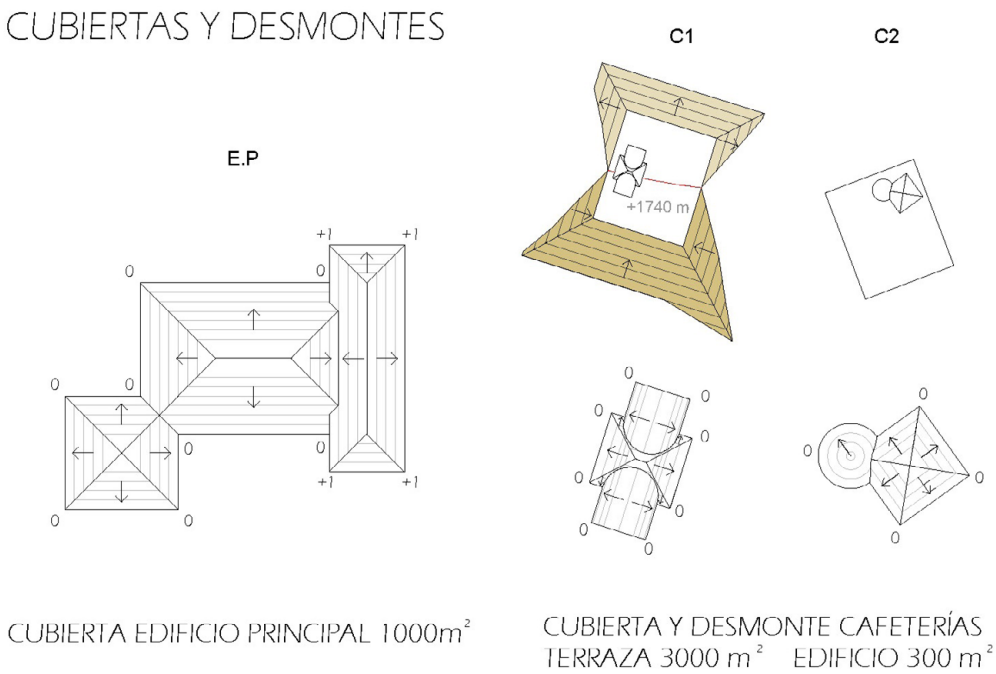

Fig. 6. Examples of some sheets of semester exercises made by the students.

correct and clear reading of the exercise is permitted, always ensuring that both procedures and solutions are not limited to each other and are adjusted to an appropriate scale. With this, the aim is to evaluate not only the correct execution of the applied procedures, but also the decisions made by the student and his ability to previously visualize the results. The versatility of the student is thus appreciated when it comes to choosing another key system for the final placement of the composition of the sheet.

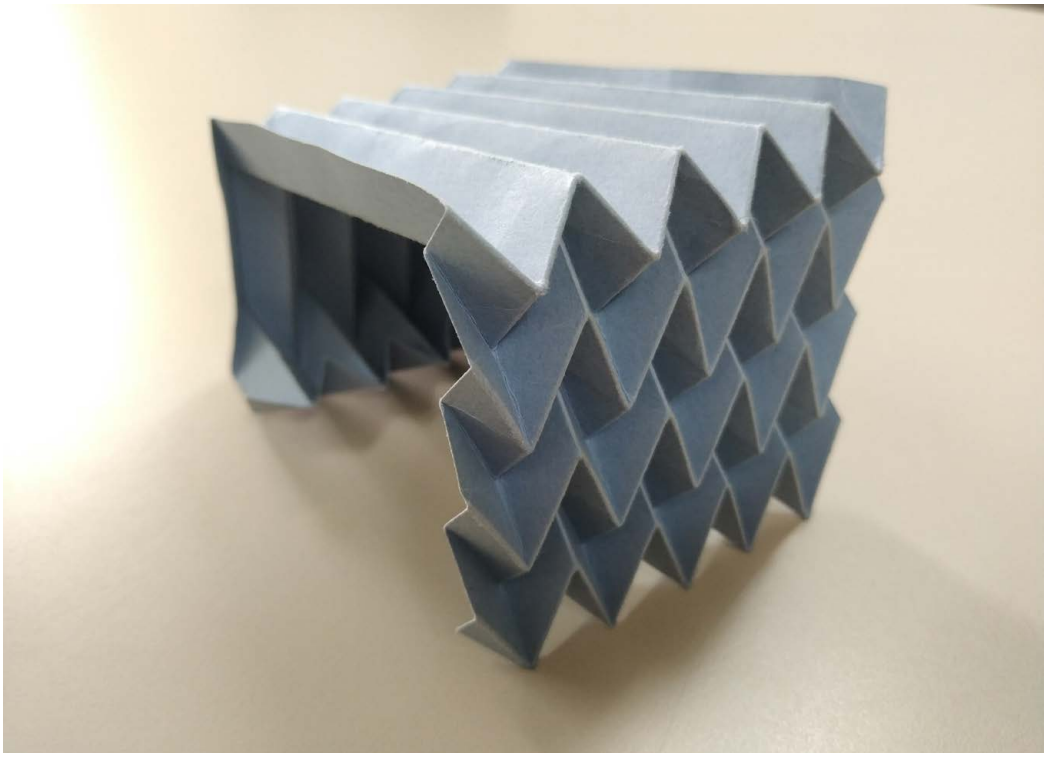

Fig. 7. Examples of working folding models.

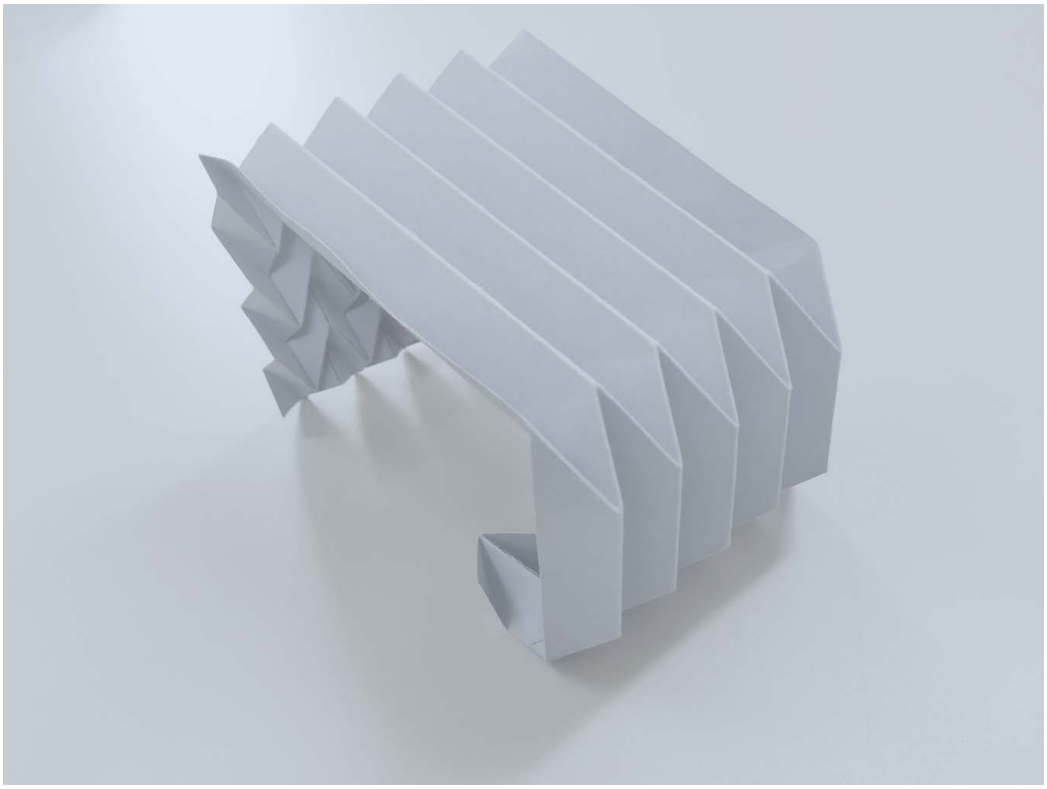

Fig. 8. Examples of working folding models.

In this way, the required template and its execution are intended for viewing the volume and verifying the processes of the diedric system in basic projects.
The correct implementation of the abatement processes, change of plane or turns, will require the correct assembly of the deployable so that each of your artists coincides exactly.
The evaluation takes into account not only the final result but also the process followed by the student.
The previous corrections are valued, the calculation and the suitability of the geometry method, the precision of the drawing, the composition, clarity and intention of the drawing and lastly, the execution of the model.

Fig. 9. The House of Music and the Theatre, located in Arroyo de la Encomienda. Photography by Ruheca.

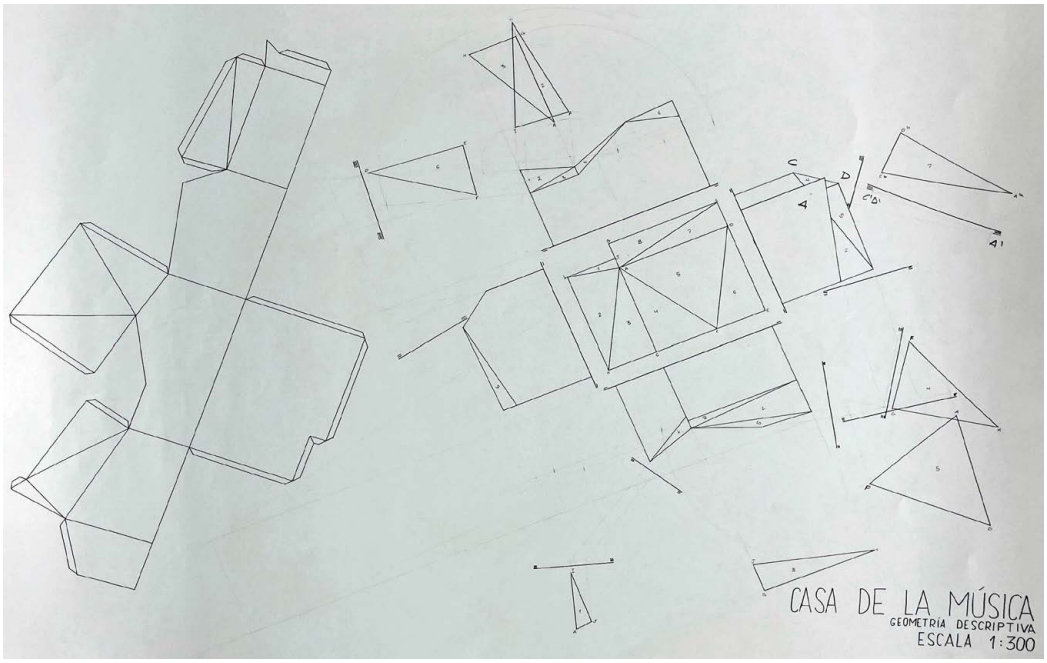

Fig. 10. Pictures of the object exercise.

Conclusions

Let's start with the fact that the designation has a degree of difficulty for students to consider. This aspect has been valued by other teachers. As Gentil indicates, in the concrete case of geometry, one cannot elude the completeness of the mystery. Bringing the ability to elaborate graphic discourse without communicative ambiguity is the goal of descriptive geometry [Gentil Baldrich 1986, p. 78].
We consider that the innovation proposal has had a positive impact on students for the following reasons.

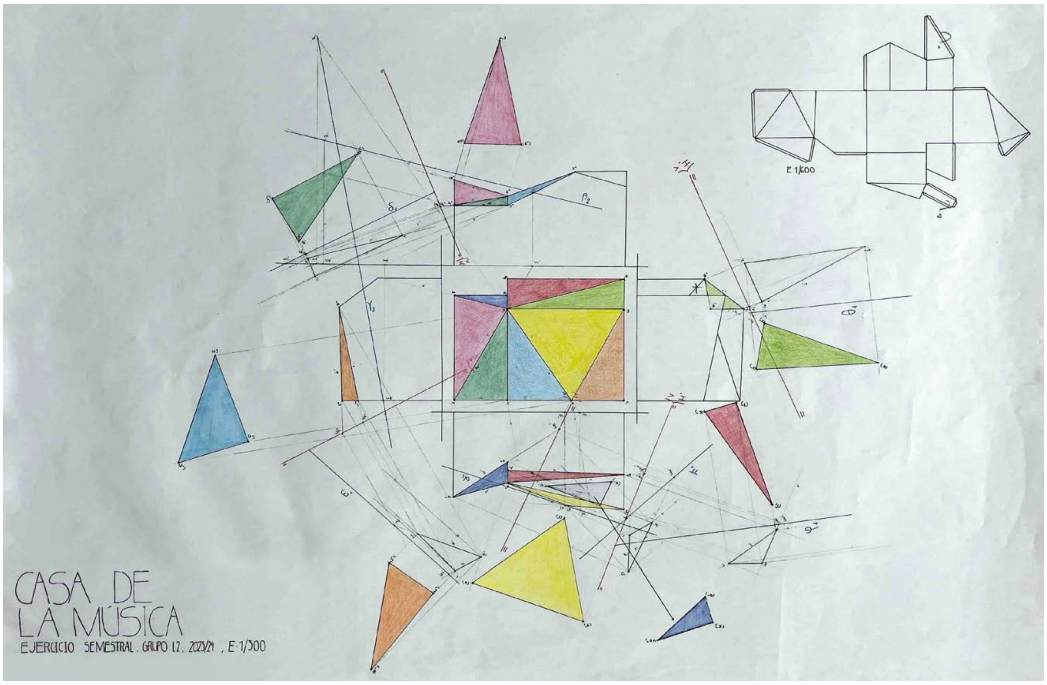

Fig. 11. Pictures of the object exercise.

If you have developed active participation and teamwork. The works were carried out in pairs, which allowed the creation of a collaborative work environment.
The connection between the theory of descriptive geometry and the study of real architectural construction has given students the possibility of understanding the practical application. Also, the fact that the exercise works with a real model that has been visited by the students has allowed it to have a deeper understanding of its space.
The work with the cut-out template allowed students to visualize, manipulate and understand the principles of geometry.
The skills that have given you this exercise will be applied in other materials such as Form Analysis, Architectural Design, or even Projects in the next course.
Skills they have learned in terms of graphic resolution of complete forms, correct composition of the sheet, choice of scale, choice of graphics, etc.
The integration of digital hardware in some cases has brought a technological component, which prepares students for actual professional environments. The software package used is CAD, if used as a clearing aid for representation, not as a 3D instrument.

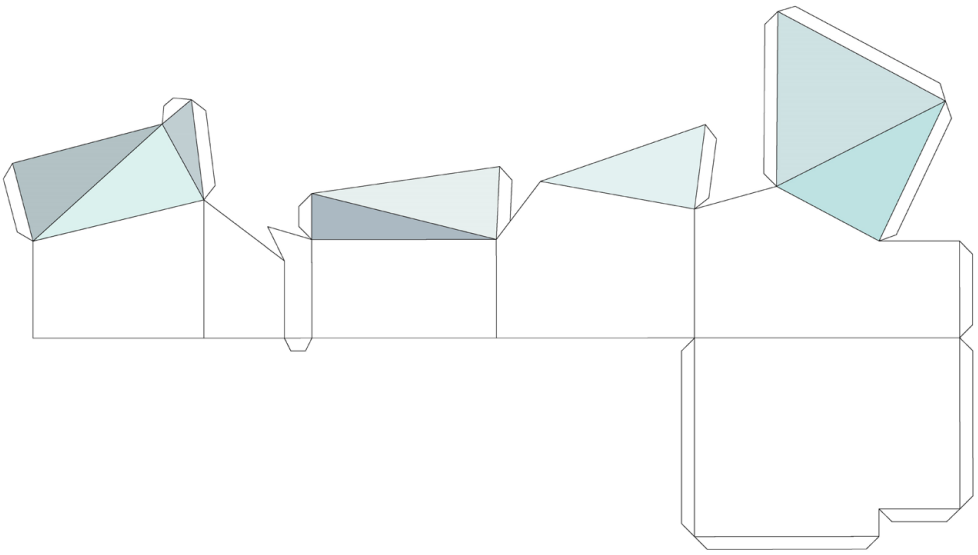

Fig. 12. Cut out of the main volume of the music house.

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