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Edited by
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Drawing and Mathematics in Art Education and Design: Interdisciplinary Approaches to Geometry

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Abstract

This paper describes a course that integrates drawing and mathematics in postgraduate art education at the University of Porto. *Interdisciplinary Approaches to Geometry* (IAG) goes beyond the traditional approach found in artistic and design-related programs, where geometry is mainly used as a representational tool. Instead, it addresses problems related to shape and space, relying on the rational model of geometry as understood from different disciplinary perspectives. Through research-based learning, students develop individual projects exploring an integrated approach to geometry. The course provides a unique dual perspective by involving instructors from both the drawing and mathematics disciplines, who teach together in all classes, ensuring a continuous multidisciplinary dialogue. The paper concludes presenting selected student projects that illustrate diverse applications and creative solutions.

Context

Traditionally, Portuguese universities offer only a single geometry course in most art degree programs, usually focused on descriptive geometry, linear perspective, and axonometry. While these skills are applied essentially for spatial representation, they often present geometry as a fixed system rather than a flexible tool for exploration. At the Faculty of Fine Arts of the University of Porto (FBAUP), however, the approach goes beyond the technical emphasis of the 19th-century French Polytechnic tradition. Here, geometry is seen as a structured method for solving spatial problems, fostering visual thinking and spatial literacy—skills that are crucial for future artists. More generally, integrating mathematics into art education enhances artistic practice by offering new ways to explore concepts such as balance, space, patterns, and relationships, all of which are fundamental to artistic expression [2]. Beyond its role in representation, geometrical reasoning can support creative exploration and problem-solving in the arts.

The literature on mathematics-art intersections has largely focused on how geometric forms influence artists, computer visualization in mathematics, and art integration in math classrooms. However, fewer studies explore the integration of mathematical reasoning in art curricula. To help fill this gap, we describe an ongoing collaboration between the Mathematics Department of the Faculty of Sciences (FCUP) and the Drawing Department of FBAUP, framing geometry not just as a representational tool but as a creative and analytical framework for artists. A key goal is to show future art teachers that mathematics offers robust results—yet many open questions remain. By learning these results, artists can create informed works while identifying uncharted areas, posing questions, or even formulating conjectures. Such engagement may, in turn, inspire new scientific inquiries.

The Course

The *Master's Degree in Teaching of Visual Arts for Teachers of the 3rd Cycle of Basic Education and of Secondary Education* (MEAV) at University of Porto is designed for the academic and professional training of future visual arts teachers, integrating scientific and pedagogical knowledge to address the challenges of contemporary art education. Typically, MEAV students have limited knowledge of mathematical principles

and are unaware of how mathematics can contribute to artistic design. This reflects a persistent divide between the arts and sciences in education, despite ongoing discussions about fostering a more integrated intellectual culture.

To bridge this gap and contribute to a shared intellectual culture, we designed *Interdisciplinary Approaches to Geometry* (IAG), a course combining perspectives from both drawing and mathematics. These disciplines have a long history of collaboration—drawing once served as proof in geometry, and although it no longer fulfills that role, it remains a powerful medium for visual exploration and creative insight. Since 2018/2019, IAG has been offered as an optional course for future art teachers (MEAV) and as a free-choice unit in other FBAUP master's programs, often attracting Design students. This reinforces the course's inter- and transdisciplinary foundations, which are vital for integrated approaches in contemporary education.

The primary objective of IAG is to foster multi-, inter-, and transdisciplinary thinking and practice, through both its structure and research-driven methodology. The course contributes meaningfully to discussions on the intersection of mathematics, art, and drawing within STEAM education, aiming to cultivate a more integrated intellectual culture. It follows a research-based learning model, treating students as active participants in a research group and the classroom as a laboratory [1]. The teaching methodology combines content exposition, discussion, fieldwork, and student-led projects, fostering a dynamic and inquiry-driven learning environment. Each three-hour class includes an exploration of a specific topic by both the mathematics and the drawing instructors, each presenting their complementary perspective.

The final hour is reserved for discussion, allowing students to critically engage with the material, ask questions, and explore interdisciplinary connections. In addition to content-based sessions, some classes focus on individual student projects, fostering a collaborative environment where students exchange ideas and provide feedback. Instructors play a key role in these discussions, ensuring the scientific validity and relevance of each project while guiding students in refining their work. The semester-long course includes 162 hours, with 45 in-class and the remainder dedicated to independent research and project development. The curriculum is structured into three interrelated thematic chapters—Creation of Form, Transformation of Form, and Representation of Form—covering topics such as geometry and cognition in drawing and art, natural and physiological bases for geometric modeling, plane polygons and polyhedra, plane tilings, geometric transformations, symmetry, fractals, anthropometry and proportion, projective versus Euclidean planes, projective transformations, and the homological functioning of representation systems. While these topics form the course's foundation, others may be added according to students' interests and project needs.

A defining feature of IAG is its research-driven project, where students apply geometry to address a self-chosen problem. While project formats can vary—ranging from designing activities for school contexts (from middle to higher education) or for general audiences in non-formal settings, to creating artworks, developing products, or conducting analyses of form—geometry must remain central. Mathematical reasoning is essential: students must explicitly engage with geometric principles (e.g., proportional systems in composition, fractals in design, geometric transformations in pattern generation). Two feedback sessions allow peers and instructors to critique progress, refining the mathematical-artistic integration. Final presentations include reflections on how geometry shaped their work.

Since its inception in 2018, the course has evolved based on student feedback and instructor observations. The integration of mathematics, drawing, and discussion has proven effective in engaging students with both disciplinary perspectives and interdisciplinary connections. Dedicated project discussion sessions have been strengthened to ensure students receive consistent guidance and structured feedback. Field trips and guest lectures have been incorporated to expand learning beyond academia and exposing students to real-world applications of geometry in art and design. One key insight from running the course over multiple years is the importance of peer interaction in project development. Collaborative discussions have become central to the learning process, reinforcing the value of diverse perspectives in shaping students' understanding of geometry's role in artistic and design practices.

Projects

This section presents selected outcomes of the course, offering brief insights into a few projects. Typically, each project spans around 30 pages, providing context, explanation, and detailed analysis. The inclusion of numerous drawn examples clarifies the mathematical principles at play while illustrating potential outcomes. A key objective of this course is to ensure that student projects are not only conceptually rigorous but also feasible for future implementation. Thus far, 61 out of the 64 enrolled students have successfully completed the course.

Typically, student projects in art education involve designing interdisciplinary school activities for middle or high school students, with geometry as a central component and content adapted to the educational context. Additionally, some projects focus on the development of educational materials.

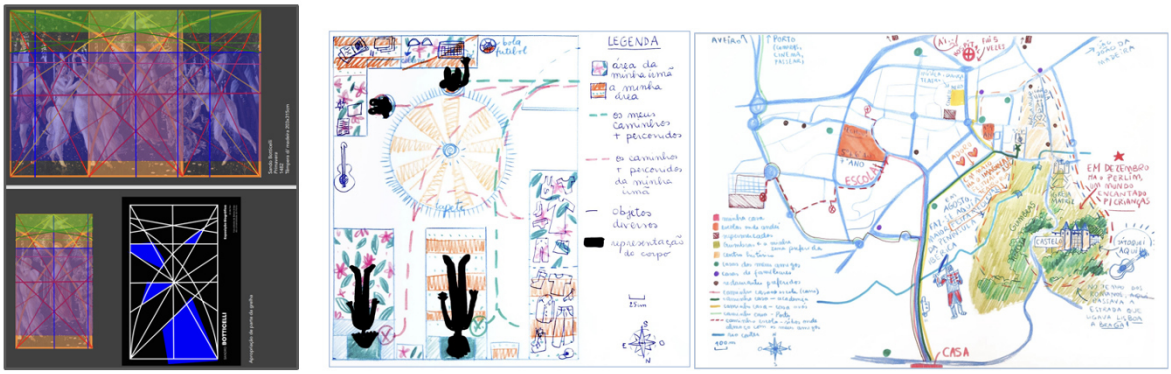

Figure 1: *"Things are Born from Things" (Catarina Dias, 2020) on the left, and "My Place in the World" (Cristiana Santos, 2021) on the right.*

In *Things Are Born from Things* (Figure 1), an activity was designed in which school students analyse the geometric composition of a painting and apply it to design a promotional poster for an exhibition featuring the same artist, engaging in mathematical reasoning through geometric construction, proportional relationships, and spatial analysis. In *My Place in the World* (Figure 1), scaled maps of the room, city, country, and world were used in an activity to explore and apply triangulation, triangle similarity, and Thales' theorem, enabling students to reason about proportion, position, and orientation in the plane.

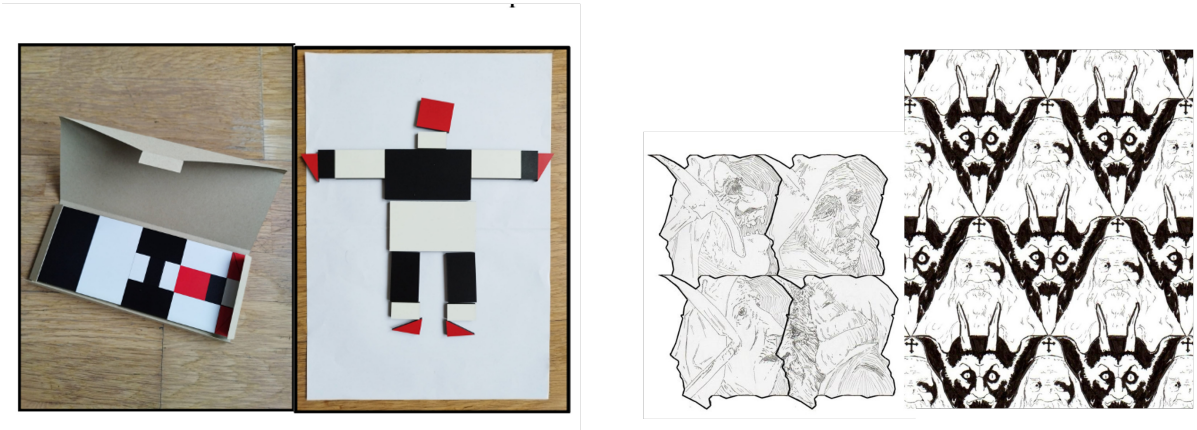

Figure 2: *"Pierrot's Project" (Diogo Jesus, 2023) on the left and "Fantastic Tales" (Manuel Santos, 2022) on the right.*

In *Fantastic Tales* (Figure 2), a classroom activity invites the exploration of plane tilings and isometries to create visual narratives set in the school environment, engaging with mathematical concepts such as regular tilings and transformation-based tile modifications that preserve edge matching, following Escher's approach. *Pierrot's Project* (Figure 2), introduces a didactic tool for exploring human body proportions. Here, algebraic formalization and geometric reasoning were employed to design modular pieces that fit precisely into a rectangular box, analysing proportional systems to solve spatial constraints.

Design students' projects primarily focus on product design and analysis of form, demanding a high level of conceptual and technical development. In *Penrose Planter* (Figure 3), Penrose tilings were used as a basis to develop a series of planters with various fitting possibilities, which led to further geometric challenges related to the production process. In *Analysis of Islamic Ceramics* (Figure 3), a collection of archaeological artifacts from Mértola was examined through geometric abstraction. The project explored whether the ceramic forms conformed to a canonical structure, using concepts such as dynamic symmetry to interpret proportional relationships and formal organization.

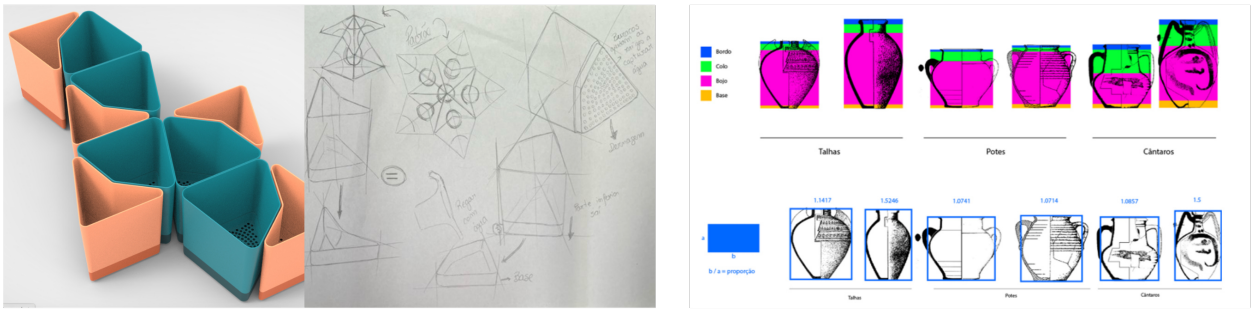

Figure 3: *"Penrose Planter" (Beatriz Oliveira, 2024) on the left and "Analysis of Islamic Ceramics" (João Mendes, 2022) on the right.*

Summary and Conclusions

The course *Interdisciplinary Approaches to Geometry* pioneers the integration of mathematics and drawing in art and design education at the University of Porto. Through research-based learning and individual projects, students explore form and space from both perspectives, enhancing spatial literacy, visual reasoning, and creativity while fostering interdisciplinary thinking within STEAM. Since its inception, 61 students have completed the course, demonstrating its potential for collaborative, boundary-breaking education. While this paper provides an overview, future publications could further examine its pedagogical framework or project outcomes.

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