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The word is the thing. Disciplinary perspectives on drawing as *graphic science*

Graphic representations today encompass an extremely wide variety of products created using both analogue tools and advanced digital technologies. These outputs can be physical or virtual, static or dynamic and animated, and are designed to fulfil a vast range of functions across countless traditions and geographical contexts. This diversity calls into question the conventional categories and definitions which, until now, have delineated the scope of knowledge relating to graphic production.
While the core subject of other sciences is clear to experts and non-experts alike—with consistent terminology across international literature—the situation is quite different for Drawing as a scientific discipline. Although generally associated with traditional modes of representation, it actually ranges from freehand drawing to advanced 3D modelling, from digital surveying to visual communication, and from graphic design to the use of AI for generating images and visualisations. This article proposes restoring the resemblance between language and the objects it names. In this sense, graphic sciences can be conceived as an overarching term capable of encompassing the entire field of scientific research and teaching related to image production. Rather than a monolithic discipline, this expression identifies a multifaceted, dynamic, and plural disciplinary landscape with which to address the future challenges of research.

Keywords:
drawing; science; scientific disciplines; history of representation

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INTRODUCTION

Through visual languages, humans have always represented reality, communicated their thoughts, explored the potential of the possible, and strengthened their cognitive and intellectual abilities across all disciplines, sciences, arts and professions. For this reason, as scientific research has evolved, drawing, visual representations and images have taken on a central role in supporting cognitive processes across various fields of application.
However, the vast variety of expressions through which humans have responded over time to their need to communicate via graphic representations now calls into question the traditional definitions and labels that, until the digital revolution, had managed to withstand the various technological, cultural and social changes that have occurred over time. Graphic representations today encompass a vast array of products, created using both analogue tools and those derived from the most advanced digital technologies, ranging from physical to virtual, and from static to dynamic and animated, designed to fulfil a wide variety of functions within countless histories and traditions specific to different cultures and geographical areas. Such a variety of products calls into question the conventional categories and definitions that had hitherto succeeded in identifying the scope of knowledge pertaining to graphic production.
The now indispensable need to engage with the international scientific community also makes it necessary for scholars in this highly specialised field to define and represent their area of work unambiguously, by adopting a definition capable of transcending the particularities of national and academic traditions. Such a definition now appears necessary as an effective communication tool not only within the fields of research and teaching, which require definitions that clearly identify the scope of action and the results to which research aspires, but also in relation to the non-expert public, who risk being confused by labels that retain their dignity and recognisability within academia but lose their meaning, or even change it, in the non-academic cultural and social contexts with which researchers nevertheless end up having to engage.
If it is clear to everyone, experts and non-experts alike, what is studied within the medical sciences, the mathematical sciences, and the chemical, physical, biological, sociological, psychological, historical, archaeological, philosophical, geographical, legal, economic, environmental, natural and agricultural sciences, and if it is easy to find coherent translations of these terms in international scientific literature and national traditions, the situation is quite different within Disegno as a scientific discipline. It is one of those cases in which the word becomes detached from the thing, transcending traditional relationships of similarity as a consequence of a new episteme that shifts from the generation of images through signs to the generation of images through algorithms.
This transformation of the disciplinary field results in low visibility compared to other fields and is therefore a disadvantage in the competition for research project funding. One need only consider what happens in the definition of the disciplinary sectors through which the *European Research Council (ERC)* organises and systematises scientific knowledge on the basis of criteria defined at European level, based on categorisations derived from the very research projects it funds. As is well known, the field of graphic representation, or a definition associated with it, is not present among the ERC sectors, and we cannot say whether this is due to a lack of funded research projects in this field or to a lack of a shared definition, which leads to projects being identified with ever-changing labels that fail to coalesce and form a critical mass capable of emerging as a recognisable group on a par with the others.

THE WORD IS THE THING

Drawing inspiration from Michel Foucault's *La parola e le cose* (1998), this article explores the theme of restoring the resemblance between language and the thing it names. In this sense, the *graphic sciences* can today be conceived as a potential umbrella term capable of encompassing the entire field of scientific research and education concerned with the production of images; an expression that would identify not so much a monolithic discipline but a multifaceted, complex, manifold, dynamic and plural disciplinary geography and genealogy, with which to address the future challenges of research, both disciplinary and, above all, interdisciplinary, which requires a strong connotation and recognisability of all the individual disciplines.
The subtitle of Foucault's book, *An Archaeology of the Human Sciences*, refers to the quasi-archaeological study of the historical conditions that gave rise to disciplines. Drawing on this suggestion in this article, we seek to interpret the stratigraphy of meanings attributed to the expression graphic science over time, in order to understand on what basis this word can be associated with its referent, namely the identification of a specific field of knowledge.
To understand how a word can describe a thing, it is useful to trace the history of how a particular verbal expression has come to take on different meanings. The term *sciences* by definition identifies a scientific approach to the act of graphic representation. Throughout the history of representation, the need for a scientific approach to drawing seems to emerge at those particular moments when the acceleration of technological progress calls into question established categories and approaches to representation. Faced with the expansion of knowledge and the emergence of new technologies, graphic representation is in fact periodically called upon to reinvent itself, to update itself, to apply itself to new and unprecedented fields, and thus to take on new and unexpected connotations that call its disciplinary frameworks into question
There are three moments, in particular, in which the scientific literature of disciplines related to drawing and representation clearly highlights the need to seek or reconstruct a scientific identity, with solid theoretical foundations, transferable operational methods and shared languages, ca-

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pable of recalibrating disciplinary frameworks that have now become inadequate to respond to the new questions emerging from society in the light of the new opportunities offered by technological progress. This is what seems to emerge from piecing together the fragments found by delving into the literature and journalistic writings, where clues suggest a stratigraphy comprising four significant events, all linked to periods of technological innovation. The first coincides with the Second Industrial Revolution of the second half of the nineteenth century, the second with the the age of automation during the economic boom of the 1960s, the third with the digital revolution of the new millennium and the fourth with the second digital revolution linked to the artificial intelligence and the machine learning. In these three periods, the term *graphic science* seems to emerge from scientific debate as a concept capable of responding to the new demands of the worlds of production, education and research.

GRAPHIC SCIENCE IN THE SECOND INDUSTRIAL REVOLUTION

The term *graphic science* is found quite widely from the nineteenth century onwards, as can be seen from the periodicals of the time, in which the term is used sometimes to describe the skills possessed by artists, and sometimes to characterise the sciences that use graphic representation as a tool for exploring knowledge. However, it was not until the second half of the century that the term came to be used not in a generic sense but to identify a specific field of knowledge. This should come as no surprise, as it is only in the last two centuries that knowledge has taken on a disciplinary form and only since the last century has it been produced within universities by specially trained individuals (Messer-Davidow, Shumway, & Sylvan 1993, Stichweh, 2001).
These early signs emerged in the Anglo-Saxon world during the Second Industrial Revolution, when three distinct approaches to drawing education began to take shape, approaches which would subsequently characterise the British educational landscape of the second half of the nineteenth century: the first was rooted in the traditions of the past, with the Royal Academy of Arts serving as its most representative institution; the second linked to the new demands of industrial production, represented by the Schools of Design and the Department of Science and Art; finally, the third, non-institutional approach, which followed the guidance of John Ruskin and focused on moving beyond a utilitarian conception of drawing towards a recognition of its role as a means of refining vision, and of acquiring and communicating knowledge on a par with reading, writing and arithmetic. According to this latter approach, drawing is conceived as a means of acquiring and communicating knowledge. Anyone who can accurately represent the form of an object and give it the correct colour has, according to Ruskin, unquestionably a greater power of notation and description. For this reason, the science of graphic notation should be regarded as that which deals with the recording of form, just as arithmetic deals with the recording of numbers (Ruskin 1905).
Although different, these three conceptions share the view of drawing as a language of form, but it is above all the second conception—that linked to production—to which we owe the first formalisation of drawing as a *science*, made necessary by the growing demand for expertise in the field of training in the reading and production of shared graphic codes capable of supporting new industrial production processes.
In 1877, in volume 30 of *The Contemporary Review*, in an article entitled *The Proposed Industrial University*, John R. St. Tyrwhitt outlined the idea of a university focused on industry; a vision that may seem obvious today but was still utopian at the time. The article discusses which subjects should be fundamental to the training of professionals for the new industry. According to the author, every art is to be understood as a craft, and every craft requires technical skills derived from the sciences. The training of these new artist-craftsmen therefore required art as much as it did technique and science. The *graphic science*, Tyrwhitt continues, are at the service of science and play a fundamental role in scientific education. The study of nature, for example, requires accurate drawing. The scientist must know what to draw, and his drawing depends on his knowledge in the field of graphic representation. University students therefore require an artistic grounding that must be developed in their prior studies; they must learn to draw 'like men of science', so as to be able to express the observations made and the knowledge acquired. Within the article, this knowledge necessary for scientific exploration is that of *graphic science*, which forms the basis of technical teaching, as drawing constitutes an indispensable language for the description of form. The methods of *graphic science*, the 1877 text continues, must be taught as a means, not as an end.
Still on the subject of education, in 1878 Walter Smith included in his volume *Practical Education. A report to the Boston School Committee* discussing the importance of drawing within school education in relation to the significant proportion of students who would in future be employed in industry and who would therefore need to know how to draw; that drawing of *graphic science* based on geometry and necessary for design. This form of drawing is defined as the language of form and, as such, is capable of being established as one of the four fundamental disciplines in children's education, alongside reading, which is necessary for acquiring knowledge; writing, which is necessary for expressing knowledge; and mathematics, which is necessary for processing knowledge.
In 1879, Samuel Edward Warren wrote an article entitled *Graphic Science in Education* in the *New England Journal of Education*, Vol. 9, No. 8. In this article, Warren argues that graphic science should be distinguished from the graphic arts. The article is devoted to discussing the content of *graphic science*: freehand drawing, lettering, geometric constructions, the use of tools and techniques, the principles of projective methods, perspective, descriptive geometry, and stereotomic modelling of forms. In Vol. 9, No. 11 of the same journal, the same author revisits and further develops his reasoning in relation to teaching, discussing *graphic*

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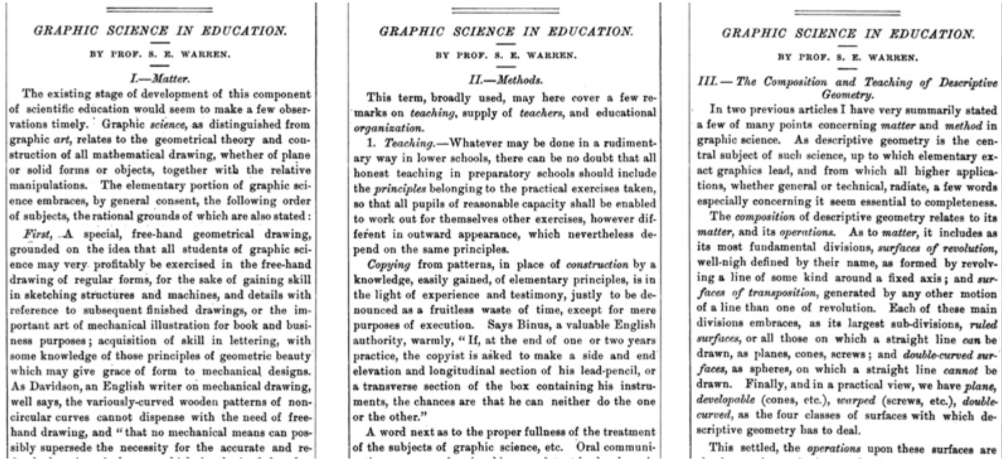
science in relation to different levels of education and its importance not only in the training of production professionals but also, more generally, in liberal education, which is not strictly technical. A third article in the same journal, in Vol. 9, No. 13, is then devoted entirely by the author to descriptive geometry and its teaching. Warren would continue to advocate the role of learning drawing as graphic science thereafter, as evidenced in the article in Education of May 1881 entitled *The mutual adjustment of secondary, collegiate, and professional education, as regards graphic science*. In 1898, in Frederick Newton Willson's volume entitled Theoretical and practical graphics: An educational course on the theory and practical application of descriptive geometry and mechanical drawing, *graphic science* is mentioned and it is highlighted that descriptive geometry constitutes its most important part. At the beginning of the 20th century, it was Alexander J. Finberg, in *Proceedings of the Aristotelian Society*, who spoke of *graphic science*, calling for a theoretical treatment of *graphic science* - understood as a language distinct from the written and spoken word but equally effective - a scientific treatment that would lead to the concept of *science*.



GRAPHIC SCIENCE IN EDUCATION.

BY PROF. S. E. WARREN.

I.—Matter.

The existing stage of development of this component of scientific education would seem to make a few observations timely. Graphic *science*, as distinguished from graphic *art*, relates to the geometrical theory and construction of all mathematical drawing, whether of plane or solid forms or objects, together with the relative manipulations. The elementary portion of graphic science embraces, by general consent, the following order of subjects, the rational grounds of which are also stated:

First, A special, free-hand geometrical drawing, grounded on the idea that all students of graphic science may very profitably be exercised in the free-hand drawing of regular forms, for the sake of gaining skill in sketching structures and machines, and details with reference to subsequent finished drawings, or the important art of mechanical illustration for book and business purposes; acquisition of skill in lettering, with some knowledge of those principles of geometric beauty which may give grace of form to mechanical designs. As Davidson, an English writer on mechanical drawing, well says, the variously-curved wooden patterns of non-circular curves cannot dispense with the need of free-hand drawing, and "that no mechanical means can possibly supersede the necessity for the accurate and re-

GRAPHIC SCIENCE IN EDUCATION.

BY PROF. S. E. WARREN.

II.—Methods.

This term, broadly used, may here cover a few remarks on *teaching*, supply of *teachers*, and educational *organization*.

1. *Teaching*.—Whatever may be done in a rudimentary way in lower schools, there can be no doubt that all honest teaching in preparatory schools should include the *principles* belonging to the practical exercises taken, so that all pupils of reasonable capacity shall be enabled to work out for themselves other exercises, however different in outward appearance, which nevertheless depend on the same principles.

Copying from patterns, in place of *construction* by a knowledge, easily gained, of elementary principles, is in the light of experience and testimony, justly to be denounced as a fruitless waste of time, except for mere purposes of execution. Says Binus, a valuable English authority, warmly, "If, at the end of one or two years practice, the copyist is asked to make a side and end elevation and longitudinal section of his lead-pencil, or a transverse section of the box containing his instruments, the chances are that he can neither do the one or the other."

A word next as to the proper fullness of the treatment of the subjects of graphic science, etc. Oral communi-

GRAPHIC SCIENCE IN EDUCATION.

BY PROF. S. E. WARREN.

III.—The Composition and Teaching of Descriptive Geometry.

In two previous articles I have very summarily stated a few of many points concerning *matter* and *method* in graphic science. As descriptive geometry is the central subject of such science, up to which elementary exact graphics lead, and from which all higher applications, whether general or technical, radiate, a few words especially concerning it seem essential to completeness.

The *composition* of descriptive geometry relates to its *matter*, and its *operations*. As to *matter*, it includes as its most fundamental divisions, *surfaces of revolution*, well-nigh defined by their name, as formed by revolving a line of some kind around a fixed axis; and *surfaces of transposition*, generated by any other motion of a line than one of revolution. Each of these main divisions embraces, as its largest sub-divisions, *ruled surfaces*, or all those on which a straight line *can* be drawn, as planes, cones, screws; and *double-curved surfaces*, as spheres, on which a straight line *cannot* be drawn. Finally, and in a practical view, we have *plane*, *developable* (cones, etc.), *warped* (screws, etc.), *double-curved*, as the four classes of surfaces with which descriptive geometry has to deal.

This settled, the *operations* upon these surfaces are

Fig. 1. Graphic Science in Education'articles on Graphic Science in the New England Journal of Education

GRAPHIC SCIENCE IN THE AGE OF AUTOMATION

In 1958, Thomas E. French and Charles J. Vierck ushered in the second phase with the publication of *Graphic Science. Engineering Drawing, Descriptive Geometry, Graphical Solutions.* In the preface to the first edition of the book, Vierck highlights how the growing complexity of our civilisation is matched by an increasing complexity in graphic representation, in response to scientific and technological advances. Drawing is regarded not merely as a language of communication but as a science encompassing both communicative aspects and methodological aspects that enable solutions to be proposed for design problems. For this reason, the preface states, the scientific approach is gradually replacing the representational one. Although the book originated in an engineering context, it is significant for its endeavour to present graphic methods as scientific, on a par with those characteristic of other sciences. A few years later, in 1963, a new preface was added to the second edition of the volume, highlighting how the approach proposed a few years earlier was now to be considered accepted by the scientific community. The text argues that the contents of graphics consist of engineering drawing as a language of communication in research, design and data construction; descriptive geometry, understood as graphical methods for problem-solving; and graphical solutions, that is, graphical methods for resolving various problems. The preface to the second edition argues that «graphics is more than a language. It is a whole division of science: the conception of space and the representation of physical objects in space, the solution of space problems, and the solution of problems of physical relationships. This is why the title of the book is "Graphic Science". No other title would portray the authors' conception as well.»
Design and graphics are thus increasingly seen not only as a language of communication but as a science that encompasses both communication and the graphic methods that enable us to address problematic situations. Although intended for teaching in the field of engineering, the book explicitly adopts a scientific approach to illustrating graphic methods. It covers many areas of interest in graphic representation: technical drawing as a language, projective methods, drawing techniques and tools, freehand drawing, descriptive geometry, lettering, charts and diagrams.
During the same period in New York, Kinelow Publishing Company published the journal *Graphic Science*, subtitled *The magazine for the draftsmen*; its stated aim was «to offer complete coverage of drafting, technical illustration and reproduction for chief draftsmen, supervisors and instructors». The opening editorial of the first issue highlights how industrial society required a shift from an empirical approach based solely on experience to a more scientific one. The editorial was written by Irwin Wladever, who at that time was also editor of another journal focusing on the same themes, *The Journal of Engineering Drawing*, which attests to a certain cultural vibrancy in the debate on the role of drawing

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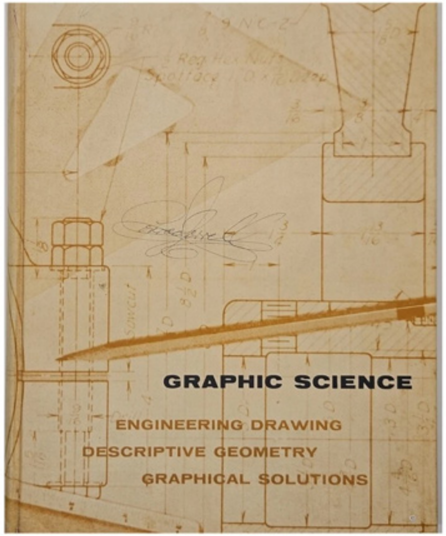
and images within society and the industrial production sector that was establishing itself in those years. On the other side of the Pacific, during the same period, the *Japan Society for Graphic Science* was founded, defining a disciplinary scope for the *graphic sciences* that encompasses not only descriptive geometry, but also engineering and architectural drawings, graphics in the arts, and all other applications of geometry and graphics (Suzuki, 2002).

GRAPHIC SCIENCE IN THE COMPUTER AGE

The third phase began in the 1990s, when a group of professors from Illinois published an article in the journal *Computer Graphics* entitled *An Engineering Graphics Curriculum Model with Multidisciplinary Implications* (McGrath et al., 1991), describing the educational content of graphic sciences, organised into subjects, skills and applications. The subjects include theory, technique and standards. Theory consists of the rules and principles used to describe geometric models, solve problems and present data. Examples of theory include plane, solid and descriptive geometry, and the theory of projections. Techniques encompass geometric methods, problem-solving and data presentation. Techniques may include the representation of real or imaginary objects using abstract primitives and conventional practices, such as lines and areas, or the use of extrusions of 2-D plane shapes into 3-D solids. Techniques also involve the use of computers to model large amounts of data for scientific visualisation. Standards refer to conventions that serve to simplify the range of choices otherwise available in the design, specification and representation of components and geometric features. Standards may include guidelines specific to a particular discipline. Among the skills to be acquired are visualisation and psychomotor skills.
Visualisation is considered in this text as an important skill for studies in many disciplines, such as engineering and the sciences, as a mental process leading to the creation of graphical information. However, students do not learn to visualise instinctively but require both planned and unplanned experiences. The ability to visualise is regarded as one of the key foundations for a graphic discipline, just as algebra is the foundation of calculus, yet it is generally never taught. A high level of visualisation ability is the most important cognitive prerequisite a student must possess to successfully represent three-dimensional objects on two-dimensional media. A curriculum lacking a visualisation component would fail to meet the student's needs.
Psychomotor activity—the muscular activity linked to mental processes—will be important for the student, as the use of tools requires a certain degree of psychomotor control. The computer, on the other hand, requires very little psychomotor practice; for this reason, its emphasis in the curriculum should be reduced, except in the critical area of sketching.
In terms of applications, the authors argue that the *graphic science* have two areas of application: artistic and technical. Historically, these were very closely linked, but eventually developed into two distinct disciplines (Land, 1976, cited in McGrath et al., 1991). Artistic drawings concern the production or deliberate arrangement of colours, shapes and other elements that influence the sense of beauty and have been used to express aesthetic, philosophical or other abstract ideas. Technical drawings concern the conception, reflection and documentation of technical ideas and are the product of the design process. It is here that we find the first explicit definition of *graphic sciences*, as the field of knowledge and study of the theory, techniques, psychomotor and cognitive foundations, and applications for all types of images. It is the theory and technique used to create real or imaginary drawings and models. *Graphic science* is the foundation of all types of drawing, the disciplinary basis that promotes graphic and visual literacy. The authors believe that the de-



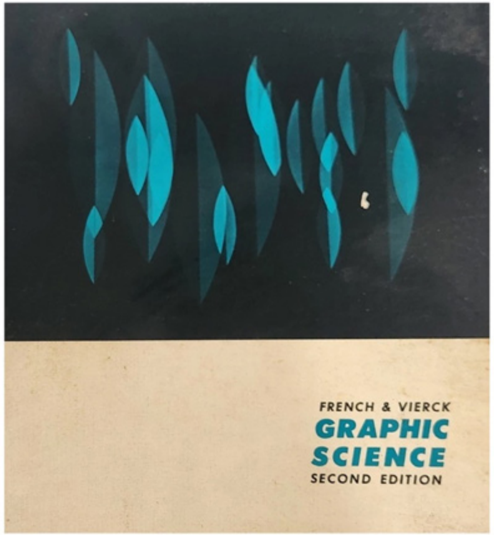


Fig. 2. Covers of the Thomas E. French and Charles J. Vierck's book, Graphic Science

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Fig. 3. Covers of the Graphic Science Journal

velopment of this conceptual model is only the beginning and not the end. A few years later, in fact, in 1998, one of the authors – Gary Bertoline – returned to the subject, preferring the term 'visual sciences' to 'graphic sciences', arguing that the latter is broader and encompasses everything that can be seen by the eye, whilst the former is limited to referring to texts and images. A few years later, in 2004, Vito Cardone, referring to these studies and experiences – on the occasion of the 4th National Congress of EGraFia (National Congress of Teachers of Graphic Expression), held at the University of Rosario in Argentina – outlined a possible horizon: that of the *Graphic Sciences*, as the name for a disciplinary field encompassing the various forms of disciplines, techniques and arts pertaining to graphic representation (Cardone, 2005). His paper was subsequently published in the conference proceedings under the title 'On the name, content, programmes and prospects for our cultural field'. It was not until 2016 that this suggestion was revisited by him in the pages of XY, in his essay 'Imagining a cultural field of visual images', published in issue 1 of the journal's new series. Not a mere suggestion, therefore, but the reiteration of a thought, with the hope that the times had since become more ripe for re-examining this idea, which had remained undeveloped since its first presentation in 2004.

GRAPHIC SCIENCE IN THE SECOND DIGITAL REVOLUTION

In light of the broadening horizons of graphic design in the new millennium and the acceleration of technological innovation - which has shifted the focus of research within the discipline towards the frontiers of the digital and virtual worlds, particularly virtual and augmented reality, parametric design and artificial intelligence - a renewed call for a disciplinary identity has gained momentum as we enter the second decade of the 21st century. Taking up Vito Cardone's initiative, the IMG2019 conference in Alghero in 2019 was dedicated to exploring the *Graphic Sciences* and defining their disciplinary boundaries. Starting from the themes, which are linked by their belonging to the sphere of the production, analysis and interpretation of images across a wide variety of fields of application, the experiment conducted through the conference culminated in the visualisation of the taxonomies of the fields of study within the *Graphic Sciences*, taking into account the new forms that drawing assumes in the light of technological development, including in the digital sphere. It is on the basis of this experience that the Italian scientific community is slowly beginning to use the word to describe something new that the word 'drawing' does not seem able to describe in a fully coherent and effective manner.
It should come as no surprise that this debate is reigniting in Italy. If one were to draw up a list of the terms used internationally to describe the field of form description, Italy remains one of the few cultures, alongside Portugal, where the word 'disegno' is used to refer to the discipline concerned with describing and representing forms. The Portuguese association A*PROGED – Associação dos Professores de Geometria e de Desenho* – and the

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Italian *UID – Unione Italiana per il Disegno* – appear to be the only ones that still associate the word 'disegno' with the concept of form representation. The word 'grafica' would appear to be the most widely accepted on the international scene and therefore the one best suited to being considered a common reference across different national and disciplinary cultures and traditions.

In Japan, the *Japan Society for Graphic Science (JSGS)* defines graphic science as 'the science that encompasses not only descriptive geometry, but also engineering and architectural drawings, graphics in the arts, and all other applications of geometry and graphics' (Suzuki, 2022). According to this approach, all applications of graphics would also be included within *graphic sciences*. *Graphic science*, writes Suzuki (2022), comprises three aspects: theoretical, technical and cognitive. The first aspect is theoretical and encompasses the theory of geometry that enables the representation of three-dimensional objects and forms the fundamental basis of *graphic science*. The second aspect is technical and currently focuses primarily on the digital tools and technologies that underpin geometric modelling today. The third aspect is cognitive or psychological, viewing graphics as a fundamental language for communication.

Since 1993, the JSGS, together with the *China Engineering Graphics Society*, has organised the *Japan-China Joint Conferences on Graphics Education*. Since the same year, the *Asian Forum on Graphic Science (AFGS)* has also been organised, a biennial international conference on graphics attended mainly by Asian countries such as China, Japan, Korea and Thailand. The conference themes focus on graphics and geometry, with particular emphasis on theory, descriptive geometry, computer graphics, modelling, applications in the fields of the arts, sciences, architecture and engineering, visualisations, images, BIM, VR, and pedagogical aspects. The focus of another major biennial international initiative, the *ICGG International Conference on Geometry and Graphics*, is exactly the same. This conference has been organised since 1978 by the *International Society for Geometry and Graphics (ISGG)*, which also publishes the Journal of Geometry and Graphics. Although these two constitute the most robust international networks from a scientific and geographical perspective, it is worth noting that research interests within the field of geometry also encompass areas of geometry that utilise representational languages other than strictly graphical ones, such as the mathematical languages of algebraic, analytical, differential and computational geometry, which require expertise falling within the scope of mathematical analysis. Along the same lines are several national scientific societies, such as, within the Germanic-speaking world, the German *DGfGG Deutsche Gesellschaft für Geometrie und Grafik* and the *Austrian Fachverband für Geometrie (ADG)*.

In Eastern Europe (Ukraine, Russia, Lithuania, Romania), reference is made to *graphic sciences* (Petrescu & Marin, 2014), 'graphic disciplines' or 'graphic-geometric disciplines' (Anamova & Khvesyuk, 2020), which mainly encompass design drawing and descriptive geometry, alongside computer graphics, drawing and painting, lettering, colour and composition (Taras, 2019; Brednyova et al., 2021; Brednyova, 2024; Vanshina et al., 2001). In the Hispanic and South American contexts too, the debate centres on the teaching of graphic disciplines within the various training curricula. Here too, graphic disciplines encompass design drawing, descriptive geometry and three-dimensional modelling (de Carvalho et al., 2017). Groups operating in the Iberian context, such as the Spanish network *EGA – Expresión Gráfica Arquitectónica*, are also more focused on the graphic field. The definition is more difficult in the French-speaking world, where, in the curriculum, graphic subjects appear under the headings of *Géométrie, Arts plastiques et visuels, and Informatique*.

CONCLUSIONS. DISCIPLINARY PERSPECTIVES ON DRAWING AS A GRAPHIC SCIENCE

This article has highlighted how the need to provide a scientific foundation for the disciplines concerned with the representation of form has emerged throughout history at times of transformation in production processes. Technological innovations and periods of industrial acceleration have prompted reflection on the need to review disciplinary frameworks in order to make them more robust and better equipped to address the emerging challenges of society and industry. In the four periods analysed – the Second Industrial Revolution, the advent of the automation era, the dawn of the computer age and the Second Digital Revolution we are currently experiencing – the term *graphic science* has reappeared in scientific discourse. This should come as no surprise, as it is precisely these moments of greatest disorientation that prompt a strengthening and adaptation of disciplinary frameworks, just as occurred with the advent of industrial-scale production first, and then with the technological revolutions linked to automation, computerisation and digitisation. In the case of disciplines dedicated to the description and representation of form, the debate has flared up to adapt the word to the thing, to ensure that the word could adapt to the evolution of the thing, in the awareness that the divergence between the word and the thing would influence the way in which we observe and understand the reality of the world. Today, it would seem that the term most widely used to denote the field of the description and representation of form in all its forms is *graphic*, which would thus appear to be the *word* that best corresponds to the *thing* itself, both in relation to the historical analysis and the geographical analysis presented in this article.

The word drawing, which has its roots in the act of making marks, can be interpreted as graphic science so as to better accommodate the shift from sign-driven representation of form to data-driven representation of form, and thus embrace methods of generating representations of forms that are increasingly less tied to the act of drawing and increasingly more tied instead to parametric and algorithmic generative processes that now increasingly characterise research, teaching and design on the contemporary international scene.

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