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Declarative and Tacit Knowledge in Vitruvius: *Disciplina*, *fabrica* and *ratiocinatio* in *De architectura* I, 1

ABSTRACT: In the opening chapter of *De architectura* Vitruvius examines the knowledge required to practice architecture and the means to acquire it. These, he claims, are manual skills and rational thought on one hand, deductive reasoning on the other. While the former suffice to make sound buildings, the latter is needed to integrate the building-to-be in the world order. A scheme emerges: the knowledge required is both procedural and declarative. Vitruvius' approach was uncommon, because it put these two kinds of knowledge on the same footing. By associating manual skill with rational thought, and claiming that it creates new knowledge, as does deductive reasoning, Vitruvius places himself on the side of modern scholarship, rather, than on that of his contemporary philosophy, as much as he depended on it.

KEYWORDS: Vitruvius, craft, manual skills, reasoning, abstraction

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In Western antiquity, the task of what was eventually called "philosophy" was the acquisition of knowledge – of the natural world in general and of the human being as individual and as a member of society. The task of architecture was the creation of appropriate buildings. Did these two very different activities share some common ground? What kind of knowledge was involved in architecture? Vitruvius, the author of *De architectura*, the only treatise on this subject that has survives from antiquity, tackles the issue in the first chapter of its first book.

In it Vitruvius appears to distinguish between declarative and procedural or tacit knowledge, both of which he considers essential for architects.

By his time there was neither a clear concept of these quite different kinds of knowledge, nor the terms to describe it. It is only natural, then, that the distinction Vitruvius makes between knowledge that can be explicitly taught and transmitted though specific oral and written instructions and knowledge that can be acquired through practice and bodily involvement is not precise. Moreover, he uses the terms that mirror this distinction without the strictness and consistency one would expect from a modern-day scientific paper. He rather lets us sense the distinction by presenting them in pair with their counterparts: *disciplinae-eruditiones, fabrica-ratiocinatio, litterae-*[*essere*] *manibus exercitati.*

The distinction between declarative and tacit knowledge seems to be crucial for Vitruvius in his attempt to define the very special character of architecture as an activity deserving respect: In the first passage of *De architectura*'s first book, and before explaining what architecture is, Vitruvius presents the kind of knowledge architects should be equipped with to successfully accomplish their mission. By exploring how knowledge of architecture is acquired, rather than stating what architecture is about, the Roman author, willingly or not, puts himself in good company: Plato opens *Meno* in a similar way, by having an interlocutor ask how is virtue acquired, and not what it actually is (Pl. *Men*. 70a). Vitruvius, then, claims that the knowledge an architect should possess stretches over various *disciplinae* and *eruditiones*, and has two sources, *fabrica* and *ratiocinatio*. Actually, the Latin original reads: "*Architecti est scientia pluribus disciplinis et variis eruditionibus ornata* [...] *Ea nascitur e fabrica et ratiocinatione*" (Vitr. I, 1, 1).

The meaning of this passage has proven controversial, and translations into modern languages vary significantly. I argue that *disciplina* has the meaning of explicit, and *eruditio* of implicit knowledge; while *fabrica*

has the meaning of craft and *ratiocinatio* of deductive reasoning, and are therefore crosswise interconnected.

The first of the controversial terms, *disciplina* occurs 15 times in book 1, of which 13 in chapter 1. It was widely used in Latin of this period and indicated all kinds of learning and study. *Eruditio* too denoted learning, teaching, knowledge, expertise, and a variety of related meanings. However, the author of *De architectura* apparently attaches different meanings to each one of them, as is evident not only in his aforementioned opening passage, but also in I, 1, 11 where he points out that architecture is a great *disciplina* adorned with a wide range of *eruditiones*.

A more detailed examination of how both terms are used in *De architectura* is therefore needed.

Vitruvius uses the term *disciplina* in general to indicate a branch of knowledge, a field of study, what we could today call a (scientific) "discipline," as is the case with the *disciplina medicinae*, the science (and art) of medicine (I, 1, 11). He uses the word *scientia* to denote knowledge related to that field; tellingly, he closes the first chapter of Book 1 by admitting that his *scientia* (knowledge) of some *disciplinae*, such as rhetoric is only mediocre (I, 1,18). He points out that he is not ignorant of several other branches of knowledge, because the various *disciplinae* are interconnected with each other (I, 1, 12), having common principles. However, since each one of them has specific requirements, no ordinary person can have in-depth knowledge of a wide range of them; only the extremely gifted people do, and they, he claims, abandon the duties of architects, and become mathematicians (I, 1, 16).

A strong indication that *disciplina* denotes a field of knowledge that can be accessed by declarative learning, can be found in I, 1, 3, where Vitruvius juxtaposes it to natural talent. He claims that for one to be an architect, they must be *ingeniosus* and *ad disciplinam docilis,* receptive of *disciplina*. *Ingeniosus* literary means inhabited or possessed by *genius*, by divine spirit. Creation driven by "divine spirit" is on the opposite end of creation resulting from a series of conscious choices. Plato called such an untamed creative force *μανία*, divine madness. As pointed out in *Phaedrus*, poems inspired by "divine madness" are incomparably better than poems created by scholars guided by reason; the latter "vanish into nothingness before that of the inspired madmen" (Pl. *Phaedr*. 245a).

But he who without the divine madness comes to the doors of the Muses, confident that he will be a good poet by art, meets with no

success, and the poetry of the sane man vanishes into nothingness before that of the inspired madmen. (Pl. *Phaedr*. 245a)

Therefore, there is good reason to believe that Vitruvius' *eruditio* is a field of knowledge acquired through means other than declarative learning.

The knowledge required to practice or, better, to perform architecture is gained, as mentioned in I, 1, 1, by *fabrica* and *ratiocinatio*. The exact meaning of these terms has proven to be notoriously difficult to pinpoint, which is made apparent in the range of translations attempted by modern scholars. Cesare Cesariano, who provided in 1521. the first translation into Italian left both terms in Latin[1]; Jean Martin, in 1547, in the first French translation, also left *fabrica* untranslated, and translated *ratiocinatio* as "discourse."[2] Daniele Barbaro, the famous Renaissance scholar and patron of Andrea Palladio, followed in Martin's footsteps.[3] Carl Watzinger, Edmond Frezouls, Louis Callebat, and Pierre Gros understand *fabrica* as the work executed manually, and *ratiocinatio* as the reflection on the work executed.[4] In the same spirit, Frank Granger translated *fabrica* as "craftmanship," and *ratiocinatio* as "calculation" or "technology," but he changed the position of the full stop between the first two sentences of I, 1, 1, so as to suggest that the architect's job – and not his knowledge – involves *fabrica* and *ratiocinatio*, whatever these terms may mean.[5]

Fabrica is the work accomplished by artisans, *fabri*, working manually to produce artefacts out of raw material. *Fabrica*, claims Vitruvius in

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[1] C. Cesariano, *Di Lucio Vitruvio Pollione de architectura libri dece traducti de latino in vulgare affigurati, commentati & con mirando ordine insigniti*, Gotardus de Ponte, Como, 1521.

[2] J. Martin, *Vitruve: Architecture, ou art de bien bastir*, J. Gazeau, Paris, 1547.

[3] D. Barbaro, *Vitruvius, De architectura*, F. Marcolini, Venice, 1556.

[4] C. Watzinger, "Vitruvstudien," *Rheinisches Museum für Philologie,* 64, 1909, pp. 202–223; E. Frezouls, "Fondements scientifiques, armature conceptuelle et *praxis* dans le *De architectura*," in J. J. De Jong, H. Geertman (eds.), *Munus non ingratum: Proceedings of the International Symposium on Vitruvius' De Architectura and the Hellenistic and Republican Architecture*, Stichting Bulletin Antieke Beschaving, Leiden, 1987, pp. 39–48; L. Callebat, "*Fabrica et Ratiocinatio dans le De Architectura*," in M. Courrént, J. Thomas (eds.), *Imaginaire et modes de construction du savoir antique dans les textes scientifiques et techniques*, Presses Universitaires de Perpignan, Perpignan, 2001, pp. 145–154; P. Gros, "Vitruve: l'architecture et sa théorie, à la lumière des études récentes," in *Vitruve et la tradition des traités d'architecture:* fabrica et ratiocinatio, l'École Française de Rome, Rome, 2006, pp. 173–209.

[5] F. Granger, "Vitruvius' Definition of Architecture," *Classical Review*, XXXIX, 3–4, 1925, pp. 67–69; F. Granger, *On Architecture*, Harvard University Press, Cambridge, Mass., 1934.

I, 1, 2 is the *continuata ac trita usus meditatio*, the continual and repeated thoughtful exercise of an activity, accomplished *manibus*, with hands (it is handwork), *ad propositum deformationis*, seeking to form (some artefact) *e materia*, out of raw material. Bodily involvement is a crucial part of any activity being categorized as *fabrica*. Thus, the crafts of carpentry and stonemasonry differ substantially from the arts of rhetoric or poetry.

Artisan activity involves repetition of movements performed almost mechanically. The repetitive character of the activity of *fabri* was snubbed by philosophers such as Plato, Aristotle, and the Stoics.

Plato held the view that artisans involved in hard manual labour are unfree people whose "souls are bowed and mutilated by their vulgar occupations" (Pl. *Resp.* 495d). The apparently spiritless repetition of movements made the philosopher claim that "the knowledge (ἐπιστήμη) possessed by the arts relating to building and to handicraft in general is inherent in their application" (Pl. *Polit*. 258d), implying that these arts are neither conscious nor intentional.[6] Of course, Plato's view on artisans and the knowledge they possess evolved over time, as did his views on art, and was not free of contradictions. In *Apology* (22d) Socrates acknowledged that artisans "knew many fine things" he was ignorant of, and therefore they were "wiser" than him. However this knowledge was not part of a wider body of knowledge, just as one would expect from a kind of knowledge "inherent in their application"; on the contrary, it was partial and obscured the "big picture," and as such detrimental to truth. As Socrates pointed out, "good artisans [...] have the same failings as the poets; because of practicing his art well, each one thought he was very wise in the other most important matters" (Pl. *Apol.* 22d).

Artisan knowledge was therefore incomparably inferior to the knowledge philosophers sought, or the επιτακτική, knowledge of "commanding" possessed by sovereigns and leaders (Pl. *Polit*. 260b; 261c); the latter was also required from architects, who supplied "knowledge, not manual labour." (Pl. *Polit*. 259e)

Zeno considered art involved in working on matter "a habitual activity ... making things by [following an established] path and [a tested] method" (SVF 72), likewise implying that it did not leave much space for the development of free will, which was severely curtailed by the constraints imposed by the material as opposed to liberal arts. Zeno's

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[6] M. Masterson, "Status, Pay, and Pleasure in the 'De Architectura' of Vitruvius," *American Journal of Philology*, 125, 2004, pp. 387–416.

approach was partly adopted later by Seneca in whose view manual *artes* do "contribute greatly toward the equipment of life [...] [but they] have nothing to do with virtue" (Sen. *Ep.* 88, 20). Admittedly, Seneca calls his guidance of Lucilius a "handiwork" (Sen. *Ep.* 34.2), but it is a quite different kind of handiwork than the one applied on shoemaking or on stonemasonry: Seneca's "handiwork" fits well into the Stoic concept of knowledge as a process involving the body: spiritus, the force that permeates nature and breathes life into it, was after all, of corporeal nature. Zeno himself pointed out the embodied character of abstract knowledge, by his famous gesticulation: the hand with fingers stressed indicated perception; with fingers slightly contracted, assent; bunched up in a fist, comprehension; and with the other hand on top, holding it tight, knowledge (Cic. *Acad*. 144–145).

To accomplish their task, the artisan employs what is nowadays called tacit knowledge.

This kind of knowledge has recently been the object of serious research by hard science.[7] Instead of being dismissed as purely automated, it is now considered an indication of expertise, and in some occasions fundamental to creative activities such as design.[8] In activities performed with bodily involvement, such as the arts and crafts related to building, the movements of skilled practitioners depend less and less on conscious choices. Motor learning progresses from cognitive to associative before becoming autonomous.[9] Initially the carpenter or builder or plasterer has to receive instructions, employ their knowledge, and follow rules in a very conscious way in order to perform a movement. Either the instructor or they pinpoint the errors in a declarative manner. Gradually, the

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[7] S. E. Dreyfus, H. L. Dreyfus, *A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition*, Storming Media, Washington, DC, 1980; F. Gobet, P. Chassy (2009), "Expertise and Intuition: A Tale of Three Theories," *Minds and Machines,* 19, 2009, pp. 151–180.

[8] D. Schoen, *The Reflective Practitioner: How Professionals Think in Action*, Routledge, London, 1992; B. Lawson, *What Designers Know*, Architectural Press, Oxford, 1988; N. Cross, "Designerly Ways of Knowing," *Design Studies*, III, 4, 1988, pp. 221–227; N. Cross, *Designerly Ways of Knowing*, Springer, London, 2006; N. Nimkulrat, "Hands-on Intellect: Integrating Craft Practice into Design Research," *International Journal of Design,* VI, 3, 2012, pp. 1–14; N. Lefa, "Can the 'Designerly Way of Thinking' Be Taught Remotely?," *Serbian Architectural Journal,* XIII, 1, 2021, pp. 39–54.

[9] L. Marinelli *et al*., "The Many Facets of Motor Learning and their Relevance for Parkinson's Disease," *Clinical Neurophysiology,* CXXVIII, 7, 2017, pp. 1127–1141; M. Filippi *et al.*, "Functional MRI in Idiopathic Parkinson's Disease," *International Review of Neurobiology*, 141, 2018, pp. 439–467.

movements consolidate, they become more accurate and refined. After a lot of practice, movements become precise and fluid, almost automated.[10] Autonomous movement is the indicator of the highest level of expertise, not of its lack.

Aristotle's approach was more nuanced. He, too, thought that artisans, in general, act as "inanimate objects." He pointed out, though, that they accomplish their task through "habit," while inanimate objects perform their activities "in virtue of a natural quality." On the other hand, master craftsmen, possess a kind of knowledge that allows them to see the big picture. They may not be better than fellow craftsmen in the accomplishment of tasks performed manually but they are "more estimable and know more and are wiser than the artisans, because they know the reasons of the things which are done" (Arist. *Met.* 981a-b).

Aristotle, then acknowledges that master-craftsmen could ascend to a level of expertise resulting in and requiring abstract thought.

Philosophers' and popular view created a vicious circle of derogation of heavy manual work. Although ancient Greek and Roman language had each a singl word, τέχνη and *ars* respectively, to name arts and crafts, mirroring a remarkable value system, the classification and comparative evaluation of τέχναι and *artes* was not uncommon; however, there was no consensus on which ones were included in each category; Varro was the only major Western scholar who in his lost treatise *Disciplinarum libri IX* listed architecture, as well as medicine, along with disciplines such as rhetoric, geometry or music.[11]

In Poseidonius' classification, adopted by the likes of Seneca the evaluation of τέχναι ranged from "common and low" to liberal (Sen. *Ep.* 88). Liberal arts were those freed from material constraints, and therefore appropriate for the social elite, political leaders and philosophers.

However, the manual construction of artefacts requires not just the skill to make complex hand movements but also the ability to solve novel problems that inevitably occur during the production of the artefact, even if this means applying known methods in different circumstances; especially if the products are highly complex such as buildings.

Moreover, the seemingly repetitive movements performed during an artisan's work are not all exactly the same, since the result of each one of

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[10] *Ibid*.
[11] G. Boissier, *Etude sur la vie et ouvrages de M. T. Varron,* Hachette, Paris, 1861, pp. 333, 336.

them is instantly evaluated so that the next movement can amend any deviations from the path leading to the desired outcome. It also requires rational thought, oversight of the whole procedure, ability to foresee eventual problems and make the right choices, and taking the necessary measures to prevent undesired effects.[12]

Vitruvius seems to have understood how complex a procedure *fabrica* is, and pointed out that it is deliberate and driven by decisions based on reason: explaining what the objective of *ratiocinatio* is, he refers to the *res fabricatas sollertiae ac rationis,* the products of dexterity and reason, closely associating the work of artisans with skill and rational thought (Vitr. I, 1, 1).

In light of this, Plato's disrespect of "knowledge of action" appears to be too biased, while Vitruvius' claim that the artisan's knowledge is a mixture of embodied expertise and rational thought seems to correspond to the conclusions of modern research. Plato's "powers of guessing, which is commonly called arts" (Pl. *Phil*. 55e) are knowledge in the full sense of the word.

The author of *De architectura*, then, held tacit knowledge to an esteem comparable to that of declarative knowledge, which aligns him with modern scholarship, rather, than with his contemporary philosophy. This kind of knowledge did not fit well with the solid and watertight theories developed during the quest for the "first causes" on which philosophers normally embarked.

Furthermore, Vitruvius points out that *fabrica* doesn't solely use knowledge; it is a means to acquire the knowledge required by architects. Aristotle had pointed to the fact that master craftsmen knew the causes of things produced, but neglected to suggest how the knowledge was acquired. The implication of Vitruvius' statement is clear: contrary to a widely held view, the Roman military engineer told his audience (among whom Augustus' sister Octavia) that manual labour, always supported by rational thought, can be beneficial to the one who performs it in that it creates new knowledge. Aristotle had probably such a development in mind when he noticed that "the man of experience is held to be wiser than the mere possessors of any power of sensation, the artisan than the man of experience, the master craftsman than the artisan" (Arist. *Met*.

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12   G. Adamson, *Thinking through Craft,* Berg, Oxford, 2009; C. Gray, G. Burnett, "Making Sense: An Exploration of Ways of Knowing Generated through Practice and Reflection in Craft," in L. K. Kaukinen (ed.), *Proceedings of the Crafticulation and Education Conference,* NordFo, Helsinki, 2009, pp. 44–51.

981b). The process of acquiring knowledge culminates in the artisan's wisdom, which transcends manual expertise and crosses into the domain of theory: "art is produced when from many notions of experience a single universal judgement is formed with regard to like objects," Aristotle noted (*Met*. 981a). Single universal judgement is equivalent to abstract thought, that can transcend the given circumstances and allow the finding of solutions to whatever difficulty arises. The kind of knowledge on which this kind of abstract thought is based is, I believe, described by Vitruvius as *eruditio*.

Ratiocinatio is according to Vitruvius what allows the products of *fabrica* to fit into the world order. Application of reason and dexterity in handwork may suffice to construct a sound building, but it is not necessarily immediately part of the world order. Only when universal laws are respected, only if there is a parallel between the principles followed by a building, and the principles governing the world can building activity be called architecture. Vitruvius is quite clear: *fabrica*, craft, suffices to erect buildings, which are products of "dexterity and reason." But, architecture happens when, on top of that, a building is made also *proportio* (Vitr. I, 1, 1), which can be understood as meaning either "proportionally," "on the basis of analogy" – in my opinion "on the basis of analogy to the cosmos, the well-ordered universe," or "with the proportions" also of the cosmos, the meaning being roughly the same.

Vitruvius presents the principles that must be followed in I, 2, 1–9; they are: order, arrangement, eurythmy, symmetry, propriety and economy. Imitation of the most sophisticated product of nature, the well-formed human body, is a shortcut for ensuring the architectural principles emulating the principles governing the world are being followed;[13] the members of the human body form an ordered whole, are well-arranged, distinguished by eurythmy, keeping with symmetry, are appropriate, and respect basic guidelines for economy, however we understand these terms.

This is what *ratiocinatio* can accomplish. But, what is it after all? *Ratiocinatio* is closely related to *ratio*, reason. But it is a special kind of reason.

Cicero, who was admired by Vitruvius (IX, Pr., 17), claimed that there are two types of argumentation, induction and *ratiocinatio*, the

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[13]   P. Lefas, "A Contemporary Reading of Vitruvius' Opening Statements and a Proposed New Partial Translation of *De Architectura* I.1," *Architectural Theory Review,* XXVI, 2, 2022, pp. 326–344.

latter being a form of argument which draws a probable conclusion from the fact under consideration itself; when this probable conclusion is set forth and recognized by itself it proves itself by its own import and reasoning" (Cic. *De inv*. I, XXXIV, 57). "Deductive reasoning" is probably the most adequate translation of Cicero's, and Vitruvius' *ratiocinatio*.

Deductive reasoning begins from general principles and moves to the specific. In some cases, it can be indistinguishable from common sense reasoning, especially if the semantic content is familiar: e.g., the most powerful people rule over their community; Augustus has become the most powerful person in Rome; Augustus will rule over Rome.

However, deductive reasoning can be highly creative – think of a difficult mathematical problem: from a set of axioms, already proven theorems, and general principles one must proceed to indisputable results; the crucial thing is to determine which axioms, which theorems, and which principles must be evoked, and in which order.[14]

Vitruvius' *ratiocinatio* is probably what needed in order for an architect to transcribe the general principles governing the world (the knowledge of which, Vitruvius implies in I. 1,15, is shared with all intellectuals) into guidelines for architecture. This transcription is a highly original and demanding process. *Ratiocinatio*, deductive reasoning, is not the theory of architecture, but the method of transcribing the "theory" common to all disciplines onto buildings-in-the-making. And it creates new knowledge.

As is the case with mathematical problems, the "solution" of architectural problems, is not straightforward. Which principles, when, in which order, have to be applied in order for the transcription of the laws governing the universe into forms made of stones and mortar to be successful, is hard to decide; and they differ from project to project.

With each new commission, which requires a fresh application of deductive reasoning, architects become more experienced, they gain more knowledge of how to solve problems, enriching their repertoire, and ultimately their expertise. *Ratiocinatio* expands the architect's *scientia* (knowledge) by allowing them to approach each time anew, from a better position, the unique challenge of designing a building.

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[14] A. Wohlgemuth, "Deductive Mathematics: An Introduction to Proof and Discovery for Mathematics Education", *Mathematics and Statistics Faculty Scholarship 1*, 2003, https://digitalcommons.library.umain.edu/mat_facpub/1 (accessed November 24, 2022).

In this sense, Vitruvius is in line with Aristotle who seems to have claimed that new knowledge can be obtained from general principles by applying deductive reasoning:

> Scientific Knowledge can be communicated by teaching, and that what is scientifically known must be learnt. But all teaching starts from facts previously known [...] since it proceeds either by way of induction (ἐπαγωγή), or else by way of deduction (συλλογισμός). Now [...] deduction works *from* universals; therefore there are first principles from which deduction starts, which cannot be proved by deduction; [...] Scientific Knowledge, therefore, is the quality whereby [...] a man knows a thing scientifically when he possesses a conviction arrived at in a certain way, and when the first principles on which that conviction rests are known to him with certainty (Arist. *NE* 1139b).

Aristotle's argument, I believe, further indicates that Vitruvius' *ratiocinatio,* deductive reasoning, is related to explicit knowledge. A bipolarity therefore is shaped: on one side are *ratiocinatio* and *disciplina*, depending on declarative knowledge, and on the other *fabrica* and *eruditio*, which depend heavily, but not exclusively, on tacit knowledge.

In his effort to help upgrade architecture as a respectable activity Vitruvius followed in the footsteps of Varro. Varro's treatise has been lost, as did several other treatises on architecture, although most of them probably dealt with specific issues or buildings, rather than general principles. We are therefore left with the question of how much of what Vitruvius writes are his own ideas or are taken from other sources. This given, Vitruvius' first set of arguments focused on clarifying that architecture requires both declarative and procedural knowledge; it requires on one hand manual skills and rational thought, and on the other hand knowledge of the principles governing the world, and the ability to transcribe them into the building-to-be.

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