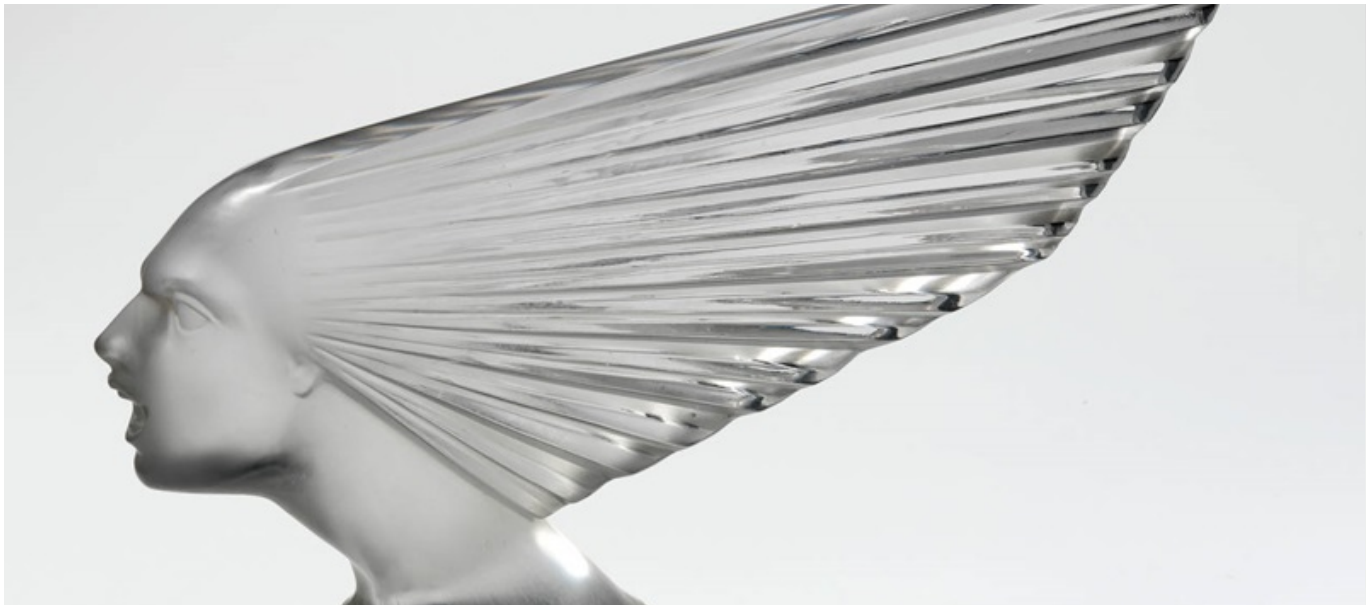

Epistemología artesanal

Posted on 31 de octubre de 2023 by Pamela Smith

Historiografía y contexto

Lo artesanal se considera a menudo un «saber cómo» y la ciencia un «saber por qué», pero el término «epistemología artesanal» cuestiona esta dicotomía al reconocer que la capacidad de los artesanos para producir cosas materiales se basa en conjuntos de conocimientos derivados de la experiencia que pueden emplearse de forma rigurosa y metódica para ampliar, categorizar, innovar y acumular nuevos conocimientos. Este punto de vista, al hacer hincapié en el trabajo corporal del artesano como fuente de conocimiento sobre el mundo, constituye un correctivo para una larga tradición filosófica que considera la «mente» y la conciencia como la principal fuente de conocimiento. Además, este término contribuye a borrar la antigua división entre «mente» y «mano» que ha informado el análisis filosófico y ha contribuido a fomentar la estratificación social durante milenios. La idea de que los artesanos poseen un modo de obtener y conceptualizar su conocimiento que puede denominarse epistemología es una innovación reciente de la historiografía de la ciencia moderna; sin embargo, varias corrientes diferentes del siglo XX en historia y ciencias sociales condujeron a la formulación de este término. La «epistemología artesanal» ha sido utilizada por los historiadores de la ciencia desde la década de 2000 en estudios que ponen en primer plano la contribución de los artesanos y practicantes a la Revolución Científica.

Aunque el término en sí es nuevo, se basa en un amplio abanico de importantes desarrollos de la filosofía, la historia y las ciencias sociales del siglo XX. El desarrollo de la fenomenología por Edmund Husserl (1859-1938) enfatizó la primacía de la percepción sensorial humana en el conocimiento del mundo. Sus seguidores, especialmente Martin Heidegger (1889-1976) y Maurice Merleau-Ponty (1908-1961), se centraron en el cuerpo y en el mundo vivido de la actividad cotidiana como lugar principal de formación del conocimiento. Según ellos, al interactuar con su entorno y aprehender el mundo a través de los sentidos, los seres humanos establecen relaciones con las cosas, a través de las cuales se crea el significado. Así pues, el cuerpo humano es la fuente de la intención humana y de la creación de sentido en el mundo. Desde esta perspectiva, las prácticas de fabricación de los oficios productivos constituyen un ámbito primordial del que surgen el conocimiento y la cultura humanos. La fenomenología ha tenido intérpretes recientes, como por ejemplo el antropólogo Tim Ingold, que considera que el desarrollo de habilidades útiles para manipular materiales naturales es característico tanto de los animales no humanos como de los humanos, y que la interacción entre los cuerpos y los entornos propicia la aparición y el crecimiento de habilidades y conocimientos (Ingold 2000; Marchand 2010). Este punto de vista tiene implicaciones explícitas para la ciencia y lo artesanal, y la obra de Ingold ha inspirado investigaciones sobre lo artesanal y los artesanos en diversas disciplinas. Recientemente, los historiadores han examinado con más detalle las circunstancias individuales de los artesanos trabajadores para argumentar que las asociaciones corporativas, como los gremios, así como las condiciones particulares del trabajo, de los cuerpos individuales y de las circunstancias materiales moldearon profundamente los métodos artesanales y los modos de trabajo (De Munck; Neilson 2014; Rublack 2023).

En las décadas de 1920 y 1930 se produjeron avances igualmente fundacionales en el ámbito de la naciente disciplina de la historia de la ciencia, cuando un puñado de filósofos, impulsados por el materialismo histórico marxista y el positivismo lógico y empírico de los miembros del Círculo de Viena, publicaron obras fundamentales sobre la historia y la filosofía de la ciencia que otorgaban un papel a los artesanos en la formación del conocimiento científico. Estos estudiosos se ocuparon del periodo que más tarde se conoció en la historia de la ciencia como «Revolución Científica», una serie de cambios en la visión del mundo, desde 1450 hasta 1750 aproximadamente, que se consideraron los primeros pasos hacia el sistema de producción de conocimiento sobre la naturaleza llamado «ciencia moderna». Estos filósofos no formaron un programa o escuela de investigación unificada, sino que se opusieron desde varios ámbitos diferentes del mundo académico y el activismo a la filosofía idealista imperante, considerando en cambio que todo conocimiento y empresa intelectual surgía de la experiencia, más que de las ideas. El más influyente de este grupo fue el físico y filósofo Edgar Zilsel (1891-1944), cuyo trabajo sobre el concepto de «genio» (y sobre

conceptos asociados como «inventor» y «artista») en el Renacimiento pretendía mostrar el modo en que las fuerzas sociales, incluido el declive del feudalismo y el auge del capitalismo, dieron lugar a la evolución de la conciencia humana y mediaron en ella. Los ensayos de Zilsel, «Problems of Empiricism» (Zilsel 1941b) y «The Sociological Roots of Science» (Zilsel 1942), esbozaron su opinión general de que la aparición de las nuevas ciencias del siglo XVII fue un proceso sociológico, enraizado en la transición del feudalismo al capitalismo temprano. Durante este periodo, a medida que crecían las ciudades y surgían nuevas tecnologías de navegación, minería y guerra con pólvora, un nuevo grupo de «artesanos superiores», como los que empezaron a llamarse arquitectos-ingenieros, así como fabricantes de instrumentos científicos y otros que utilizaban matemáticas prácticas, como topógrafos y navegantes, aportaron un nuevo enfoque experimental y una nueva idea de progreso que interesaron y fueron absorbidos por los que empezaron a llamarse «nuevos filósofos» y «filósofos experimentales» desde principios del siglo XVII (Raven et al. 2003). Dos décadas más tarde, Paolo Rossi se basó fehacientemente en el trabajo de Zilsel, argumentando que los artistas y artesanos de principios de la Edad Moderna formularon los valores que nutrieron a la ciencia moderna, entre ellos la naturaleza progresiva y acumulativa del conocimiento científico, la opinión de que la tecnología es perfectible y la idea de que el conocimiento científico consiste en saber cómo funciona o se fabrica un mecanismo, en lugar de conocer las causas, como habían enseñado Aristóteles y los escolásticos (Rossi 1957, 1962).



Reunión del Círculo de Viena, 1939.

Al mismo tiempo, otros filósofos, también influidos por el marxismo pero que partían de una perspectiva diferente a la de Zilsel, sostenían que el auge de las máquinas y las nuevas tecnologías de producción capitalista habían dado lugar a una imagen mecanicista «moderna» del mundo. Entre ellos, el físico ruso Boris Hessen (1893-1936) fue quizá más conocido en el mundo anglófono por su artículo de 1931, «The Social and Economic Roots of Newton's *Principia*», en el que exponía su opinión de que el surgimiento de la nueva ciencia de Galileo y Newton fue un subproducto de los modos de producción capitalistas y sus tecnologías. La mecánica de Newton, por ejemplo, surgió de los nuevos tipos de máquinas utilizadas en la guerra, la minería, la navegación y otras áreas del capitalismo mercantil del siglo XVII (Hessen 1931). Los individuos asociados con lo que se conoció como la Escuela de Fráncfort, caso de Franz Borkenau (1900-1957), que publicó *The Sociology of the Mechanistic World Picture* en 1932, desarrollaron puntos de vista similares sobre los orígenes sociales del cambio científico, especialmente en su evaluación de la centralidad de las prácticas y los profesionales de los campos técnicos en el auge de las visiones mecanicistas del cosmos.

Las investigaciones y publicaciones surgidas en ámbitos completamente distintos de la

erudición académica también contribuyeron a la opinión de que la práctica constituía la base de la nueva ciencia. Por ejemplo, el estudioso de la literatura Leonardo Olschki (1885-1961) dio a conocer el contenido de muchos escritos prácticos de los siglos XVI y XVII que, en su opinión, influyeron en un nuevo científico como Galileo Galilei (Olschki 1927). En una línea similar, pero basándose en un corpus diferente de escritos prácticos, el historiador estadounidense Lynn Thorndike (1882-1965) argumentó en *A History of Magic and Experimental Science* (ocho vols., 1923-1958) que las raíces de la ciencia experimental se encontraban en la visión operativa del mundo y en las acciones prácticas de los practicantes de magia, tal y como se expresaban en los libros de magia, recopilando finalmente ocho volúmenes de escritos sobre magia práctica (Thorndike 1923-1958). Afirmaba que «los magos fueron quizá los primeros en experimentar, y la historia de la magia y de la ciencia experimental puede entenderse mejor estudiándolas juntas» (Thorndike 1923, I.2). Aproximadamente al mismo tiempo, pero desde la sociología, el sociólogo estadounidense Robert Merton (1910-2003), en su publicación de 1938, *Science, Technology, and Society in Seventeenth-Century England*, argumentó que el desarrollo de nuevas tecnologías, especialmente asociadas con el auge del comercio en la Inglaterra del siglo XVII, fue crucial para el desarrollo del empirismo (Merton 1938). La obra de Merton fue retomada por los sociólogos del conocimiento y, en los años ochenta, por los historiadores de la ciencia.

Antes de la década de 1980, muchos historiadores de la ciencia anglófonos, influidos esencialmente por la obra de Alexandre Koyré (1892-1964), A. R. Hall (1920-2009) y Thomas Kuhn (1922-1976), rechazaban el enfoque de Zilsel e incluso de Merton, negando toda importancia a la práctica y a los profesionales en la elaboración del conocimiento científico (Koyré 1968; Hall 1959; Kuhn 1977). La situación en Francia, sin embargo, era bastante diferente, donde la historia social francesa, principalmente la practicada por la llamada escuela de los Annales, cuyos miembros examinaron con amplio detalle las condiciones históricas de la vida en las aldeas y ciudades francesas preindustriales, puso en primer plano los documentos históricos y los escritos de los trabajadores agrícolas, artesanos y otros profesionales (Febvre 1935; Long 2005). El agrónomo François Sigaut (1940-2012), cuyas actividades profesionales le llevaron por toda Francia y el África francesa, formuló un enfoque de la historia de la tecnología centrado en los «gestos» y técnicas corporales de las prácticas agrícolas preindustriales europeas y africanas (Sigaut 1994). Su trabajo influyió en las ciencias humanas y la historia de la ciencia en Francia en las décadas de 1990 y 2000 (Bouillon et al. 2017; Cardinal et al. 2016). También surgió de la historia social francesa el giro hacia la historia cultural y la microhistoria de historiadores como Natalie Zemon Davis, Carlo Ginzburg y James Amelang, que sacaron a la luz las vidas y visiones del mundo (*mentalité*) de los no pertenecientes a las élites, incluidos los artesanos (Davis 1975; Ginzburg 1992; Amelang 1998). Desde la dirección de una nueva historia social del arte,

especialmente en la obra de Michael Baxandall (1933-2008), también se empezaron a explorar el «estilo cognitivo» y el «period eye» de los artistas del Renacimiento, que hacían hincapié en las dimensiones cognitivas e intelectualizadoras del trabajo artístico (Baxandall 1972, 1980; Alpers 1983). Los teóricos de la artesanía moderna preocupados por analizar el papel del diseño en lo artesanal y el arte también han sido influyentes a la hora de explicar la unión de la mano y la mente implicada en la fabricación, a veces denominada «inteligencia de la mano», «inteligencia material» o «cognición del hacer» (Pye 1968; Dormer 1994, 1997; Tallis 2003; Sennett 2008; Bernardoni 2011; Adamson 2007, 2013; Neilson 2019; Lehmann 2009). Los historiadores del arte y lo artesanal tomaron del trabajo del psicólogo James Gibson la teoría de las «affordances» (posibilidades) y «constraints» (limitaciones) impuestas por las propiedades de los materiales sobre los cuerpos y el trabajo de los artesanos (véase Lehmann 2015).

Al mismo tiempo, el auge de la antropología social, en especial de E. E. Evans-Pritchard (1902-1973) en su estudio de la magia y la brujería de los azande (Evans-Pritchard 1937), llamó la atención de los filósofos de la ciencia en los años sesenta y setenta, que lo utilizaron para defender la simetría de la «ciencia» y la «pseudociencia» como sistemas de conocimiento. A raíz de este trabajo, se multiplicaron los estudios sobre los sistemas de conocimiento indígenas en antropología y en antropología de la ciencia, lo que llevó a la idea de que la ciencia moderna puede considerarse simplemente como otro sistema de conocimiento de este tipo (Watson-Verran y Turnbull, 1995). En una serie de importantes estudios etnográficos sobre las «matemáticas cotidianas», el antropólogo social Jean Lave dejó claro que la cognición tiene lugar en las prácticas cotidianas (Lave 1988; Lave y Wenger 1991; Chaiklin y Lave 1993).



Guerreros azande, circa 1918.

Todas estas corrientes académicas supusieron un cambio radical en la historia de la ciencia preindustrial, ya que validaron el estudio de los sistemas de conocimiento y de los profesionales que no podían encajar en una historia teleológica lineal del desarrollo de la ciencia moderna. La idea de que la historia de la ciencia no tenía por qué tener como tarea la explicación de cómo surgió el estado actual del conocimiento científico ha dado lugar, desde principios de la década de 1980, a un cambio significativo en la concepción de los objetivos de la historia de la ciencia, que pasó a incluir la historia de «callejones sin salida» como la alquimia y la astrología, la ignorancia y los sistemas de conocimiento de los artesanos y profesionales (Smith 2009).

Otros dos avances en el estudio de la ciencia, la tecnología y la medicina han dado lugar a exploraciones más intensas del conocimiento artesanal. El primero tuvo lugar en la década de 1980 en varios centros, como París, Edimburgo y varias universidades del Reino Unido, cuando los sociólogos del conocimiento empezaron a centrarse en la construcción social del conocimiento científico (Golinski 2005). Su investigación incluía cierta exploración del trabajo

de laboratorio, como la relación entre técnica y teoría, y el papel de los técnicos de laboratorio y su conocimiento corporal en la empresa científica, pero, en general, esa exploración no era su objetivo principal. Sin embargo, su trabajo ayudó a inspirar un estudio sobre las formas en que el «conocimiento gestual» del cuerpo (influenciado también por el trabajo de François Sigaut) desempeñó un papel crucial en los experimentos científicos históricos (Sibum 2000; Chang 2011; Fors et al. 2016). Mientras tanto, en *Personal Knowledge*, el químico y filósofo Michael Polanyi (1891-1976) se centró explícitamente en el conocimiento corporal y tácito en las ciencias naturales (Polanyi 1958; Collins 2010). A partir de esta investigación sobre el conocimiento tácito y gestual, los historiadores de la ciencia empezaron a explorar la metodología de recrear experimentos científicos para comprender mejor su curso histórico real. Recientemente, este método de reconstrucción se ha extendido más ampliamente al conocimiento histórico experiencial y a las prácticas artesanales (Smith 2012, 2016; Smith et al. 2016; Fors et al. 2016; Taape et al. 2020; Dupré et al. 2020; Making and Knowing Project et).

Artesanos y conocimiento natural

Todos estos avances en el estudio del conocimiento científico abrieron el camino para que el saber corporal de los artesanos se considerara significativo —incluso central— para el estudio y la comprensión de las epistemologías del conocimiento natural. Aproximadamente a partir de la década de 1990, los historiadores de la ciencia empezaron a estudiar una gama muy diversa de practicantes —incluidos los artesanos— que no eran principalmente eruditos formados en la universidad ni «nuevos filósofos experimentales», sino que se relacionaban con la naturaleza y los materiales naturales de formas muy diversas, incluida la transformación directa de materiales naturales como parte de un oficio o de la alquimia, la formulación de sistemas de conocimiento vernáculos sobre procesos naturales o la invocación de la autoridad de la naturaleza para hacer afirmaciones con valor de certeza. Los historiadores de la ciencia que estudiaron a este grupo diverso de practicantes, en su mayoría no elitistas, formularon las nociones de «el conocimiento de los fabricantes», «ciencia vernácula» y «epistemología artesanal», expresando la idea nueva de que los artesanos poseían una filosofía, una ciencia o un «sistema de conocimiento» (van Berkel 1985; Pérez-Ramos 1988; Egmond 1999; Smith 2004 y 2022; Roberts et al. 2007; Harkness 2007; Long 2011). En contraste con las concepciones anteriores de lo artesanal, estos historiadores cuestionaron que las prácticas artesanales fueran memorísticas y mecánicas, argumentando en su lugar que los artesanos llevaban a cabo sus técnicas a la luz de un conjunto coherente de principios, pero a menudo codificados en objetos, herramientas, rituales o incluso en canciones, aforismos y proverbios, en otras palabras, en tipos de externalización del conocimiento distintos a los trabajos escritos.

Estos historiadores han descrito, por ejemplo, la epistemología vernácula de las comadronas (Fissell 2006) y la epistemología artesanal de los artistas, incluidos pintores, escultores y metalúrgicos (Smith 2001, 2004, 2010, 2011). La epistemología artesanal, tal y como aparece en las prácticas artesanales preindustriales y en los escritos de los profesionales y sus libros de recetas, incluye las afirmaciones de los artesanos de que la naturaleza y la experiencia son la base de su conocimiento, un conocimiento cierto o positivo contenido en los materiales de la naturaleza, que debe ser extraído por el práctico a través de la lucha corporal (Leong 2018). Su búsqueda del conocimiento es, por tanto, activa: conocer es hacer. Este proceso de lucha a menudo toma el nombre de «experiencia» y se aprende y explica a través de la imitación y replicación de los procesos naturales. Esta imitación de la naturaleza produce un efecto —una intervención en el mundo material, como una obra de arte— que a la vez muestra y constituye un conocimiento. Bernard Palissy (ca. 1510-ca. 1589), ceramista y escritor, expuso explícitamente este punto de vista en sus escritos, llamando a este conocimiento «filosofía de los obreros». Él y otros artesanos, como Alberto Durero (1471-1528), consideraban este método de imitación de la naturaleza como un proceso cognitivo (Lestringant 1992; Smith 2004). Para estos artistas, la imitación como modo de adquirir conocimientos constituía simultáneamente un esfuerzo estético, la creación de una epistemología artesanal (a veces en forma textual y a veces en la forma material de las cosas hechas), una investigación de las propiedades de los materiales naturales y, en su forma más básica y universal, era simplemente un modo de realizar un trabajo cualificado (Smith et al. 2016; Smith 2022).

La epistemología de los artesanos surgió en parte de su formación como aprendices, en la que las técnicas corporales de observación, imitación, repetición y práctica activa eran modos de trabajo y transmisión del conocimiento. Esta epistemología, tal y como se diseñaba en los textos, en las conversaciones con eruditos y mecenas, y en las obras de arte naturalistas, sugería que el acceso directo a la naturaleza era posible y necesario, que el conocimiento se adquiría a través del compromiso corporal con la materia, que el conocimiento «científico» (en el sentido aristotélico de *scientia*) podía extraerse de la naturaleza, y que la imitación de la naturaleza producía conocimiento productivo. La emergencia de esta epistemología —en parte por los propios artesanos y en parte por intermediarios como Theophrastus von Hohenheim, llamado Paracelsus (1493-1541), y Georgius Agricola (1494-1555)— creó una identidad a través de la cual los profesionales podían expresar reivindicaciones de autoridad sobre la base de su conocimiento de los procesos naturales, adquirido con tanto esfuerzo (Smith 2004, 2014, 2015). Así pues, la epistemología artesanal desempeñó un papel importante en la Revolución Científica, ya que, mediante la materialización de esta epistemología vernácula en objetos y textos, los artesanos europeos de los siglos XV y XVI se comprometieron a hacer que el acceso directo a

la naturaleza y la producción de efectos contaran como *scientia*, es decir, como conocimiento cierto y positivo (Smith 2004).

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Artisanal Epistemology

Craft is often viewed as “knowledge how” and science as “knowledge why,” but the term “artisanal epistemology” challenges this dichotomy to recognize that the ability of craftspeople to produce material things rests upon experientially derived bodies of knowledge that can be employed rigorously and methodically to extend, categorize, innovate, and accumulate new knowledge. This view, in emphasizing the bodily labor of the craftsperson as the source of knowledge about the world, constitutes a corrective to a long philosophical tradition that views “mind” and consciousness as the primary source of knowledge. The idea that artisans possess a mode of gaining and conceptualizing their knowledge that can be named an epistemology is a recent innovation of the historiography of early modern science; however, several different twentieth-century currents in history and the social sciences led up to the formulation of this term. “Artisanal epistemology” has been used by historians of science since the 2000s in studies that foreground the contribution of artisans and practitioners to the Scientific Revolution.

Artisanal Epistemology – Historiography and Context

The idea that artisans possess a mode of gaining knowledge that can be called an epistemology is a recent innovation of the historiography of early modern science. Craft is often viewed as “knowledge how,” while science is seen as “knowledge why,” but the term “artisanal epistemology” challenges this facile dichotomy to recognize that the ability of craftspeople to produce material things rests upon experientially derived bodies of knowledge that can be employed rigorously and methodically to extend, categorize, innovate, and accumulate new knowledge about nature. This view, in emphasizing the bodily labor of the craftsperson as the source of knowledge about the world, constitutes a corrective to a long philosophical tradition that views “mind” and consciousness as the primary source of all knowledge. Moreover, this term works to erase the long-standing division between “mind” and “hand” that has informed philosophical analysis and helped foster social stratification for millennia.

Although the term itself is new, it rests upon a wide swath of important developments in twentieth-century philosophy, history, and the social sciences. The development of phenomenology by Edmund Husserl (1859–1938) emphasized the primacy of human sensory perception in knowing the world. His followers, especially Martin Heidegger (1889–1976) and Maurice Merleau-Ponty (1908–1961), developed a focus on the body and the lived world of everyday activity as the primary site of knowledge formation. As they saw it, as human beings interacted with their environment, and as they apprehended the world through their

senses, they enter into relationships with things, through which meaning is made. The human body, then, is the source of human intention and of meaning-making in the world. From this perspective, the making practices of the productive crafts constitute a prime realm from which human knowledge and culture emerge. Phenomenology has had recent interpreters, for example, the anthropologist Tim Ingold, who regards the development of useful skills of manipulating natural materials as characteristic of both nonhuman and human animals, with the interaction between bodies and environments bringing about the emergence and growth of skills and knowledge (Ingold 2000; Marchand 2010). This view has explicit implications for science and craft, and Ingold's work has inspired research on crafts and craftspeople in a variety of disciplines. Recently, historians have examined in more detail the individual circumstances of laboring craftspeople to argue that corporate associations, such as guilds, as well as the particular conditions of labor, of individual bodies, and of material circumstances profoundly shaped artisanal methods and modes of working (De Munck; Neilson 2014; Rublack 2023).

Similarly foundational developments from the realm of the nascent discipline of the history of science occurred in the1920s and 1930s when a handful of philosophers, impelled by Marxist historical materialism and the logical and empirical positivism of members of the Vienna Circle, produced germinal works on the history and philosophy of science that gave a role to artisans in the formation of scientific knowledge. These scholars were concerned with the period that later became known in the history of science as "the Scientific Revolution"– a series of shifts in worldview from about 1450 to about 1750 that were viewed as the first steps toward the system of knowledge and knowledge production about nature called "modern science." These scholars did not form a unified research program or school, but rather opposed from several different realms of scholarship and activism the prevailing idealist philosophy, instead viewing all knowledge and intellectual change as arising from experience, rather than from ideas. Most influential of this group was the physicist and philosopher, Edgar Zilsel (1891–1944), whose work on the concept of "genius" (and on associated concepts such as "inventor" and "artist") in the Renaissance sought to show the ways in which social forces, including the decline of feudalism and the rise of capitalism, gave rise to and mediated developments in human consciousness. Zilsel's essays, "Problems of Empiricism" (Zilsel 1941b) and "The Sociological Roots of Science" (Zilsel 1942), outlined his general view that the emergence of the new sciences of the seventeenth century was a sociological process, rooted in the transition from feudalism to early capitalism. During this period, as towns grew and new technologies of shipping, mining, and gunpowder warfare emerged, a new group of "superior artisans," such as those who began to call themselves architect-engineers, as well as scientific instrument makers and others who used practical mathematics, such as surveyors and navigators, brought about a new experimental approach

and a new idea of progress that informed and was absorbed by those who began to call themselves “new philosophers” and “experimental philosophers” from the early seventeenth century (Raven et al. 2003). Two decades later, Paolo Rossi built upon Zilsel’s work in important ways, arguing that artists and practitioners in the early modern period formulated the values that informed modern science, among them the progressive and cumulative nature of scientific knowledge, the view that technology is perfectible, and the idea that scientific knowledge con- sists in knowing how a mechanism works or is made, rather than knowing the causes, as Aristotle and the scholastics had taught (Rossi 1957, 1962).

At the same time, other philosophers, also influenced by Marxism but starting from a different perspective than Zilsel, argued that the rise of machines and new technologies of capitalist production gave rise to a “modern” mechanistic picture of the world. Of these, the Russian physicist Boris Hessen (1893–1936) was perhaps best known in the Anglophonic world for his 1931 paper, “The Social and Economic Roots of Newton’s *Principia*,” which laid out his view that the rise of the new science of Galileo and Newton was a by-product of capitalist modes of production and their technologies. Newton’s mechanics, for example, arose out of the new types of machines used in warfare, mining, shipping, and other areas of merchant capitalism of the seventeenth century (Hessen 1931). Scholars associated with what became known as the Frankfurt School, such as Franz Borkenau (1900–1957) who published *The Sociology of the Mechanistic World Picture* in 1932, developed similar views about the social origins of scientific change, especially in his assessment of the centrality of practices and practitioners of technical fields in the rise of mechanical views of the cosmos.

Research and publications emerging from completely different realms of scholarship also contributed to the view that practice formed the basis of the new science. For example, the literary scholar Leonardo Olschki (1885–1961) made known the contents of many practical writings of the sixteenth and seventeenth centuries, which he viewed as influencing the new scientist, Galileo Galilei (Olschki 1927). In a similar vein, but based on a different body of practical writings, Ameri- can historian Lynn Thorndike (1882–1965) argued in *A History of Magic and Experimental Science* (eight vols., 1923–1958) that the roots of experimental science lay in the operative world- view and practical actions of practitioners of magic, as expressed in books of magic, eventually collecting together eight volumes of writings on practical magic (Thorndike 1923–1958). He claimed that “magicians were perhaps the first to experiment; and that the history of both magic and experimental science can be better understood by studying them together” (Thorndike 1923, I.2). At roughly the same time, but from the direction of sociology, American sociologist Robert Merton (1910–2003), in his 1938 publication, *Science, Technology, and Society in Seventeenth-Century England*, argued that the development of new technologies especially associated with the rise of commerce in

seventeenth-century England was crucial to the development of empiricism (Merton 1938). Merton's work was taken up by sociologists of knowledge and eventually in the 1980s by historians of science.

Before the 1980s, many Anglophonic historians of science, influenced especially by the work of Alexandre Koyré (1892–1964), A. R. Hall (1920–2009), and Thomas Kuhn (1922–1976), rejected the approach of Zilsel and even of Merton, denying any importance to practice and practitioners in the making of scientific knowledge (Koyré 1968; Hall 1959; Kuhn 1977). The situation in France, however, was quite different, where French social history, especially that practiced by the so-called *Annales* school, whose members examined in extensive detail the historical conditions of life in preindustrial French villages and towns, brought to the fore historical documents and writings of agricultural laborers, craftspeople, and other practitioners (Febvre 1935; Long 2005). An agronomist, François Sigaut (1940–2012), whose professional activities took him throughout France and French Africa, formulated an approach to the history of technology that focused on bodily "gestes" and techniques in preindustrial European and African agricultural practices (Sigaut 1994). His work was influential in the human sciences and history of science in France in the 1990s and 2000s (Bouillon et al. 2017; Cardinal et al. 2016). Also growing out of French social history was the turn to cultural history and microhistory by historians such as Natalie Zemon Davis, Carlo Ginzburg, and James Amelang that brought to light the lives and worldviews (*mentalité*) of non-elites, including craftspeople (Davis 1975; Ginzburg 1992; Amelang 1998). From the direction of a new social history of art, especially in the work of Michael Baxandall (1933–2008), the "cognitive style" and "period eye" of Renaissance artists also began to be explored, which emphasized the cognitive and intellectualizing dimensions of artistic work (Baxandall 1972, 1980; Alpers 1983). Theorists of modern craft concerned to articulate the role of design in craft and art have also been influential in explicating the union of hand and mind involved in making, sometimes called "intelligence of the hand," "material intelligence," or "cognition of doing" (Pye 1968; Dormer 1994, 1997; Tallis 2003; Sennett 2008; Bernardoni 2011; Adamson 2007, 2013; Neilson 2019; Lehmann 2009). Art and craft historians took over from the work of psychologist James Gibson the theory of "affordances" and "constraints" imposed by the properties of materials on the bodies and work of artisans (see Lehmann 2015).

At the same time, the growth of social anthropology, especially as pursued by E. E. Evans-Pritchard (1902–1973) in his study of the magic and witchcraft of the Azande (Evans-Pritchard 1937), came to the attention of philosophers of science in the 1960s and 1970s who made use of it to argue for the symmetry of "science" and "pseudoscience" as knowledge systems. In the wake of this work, studies of indigenous knowledge systems in anthropology and in the anthropology of science multiplied, leading to the view that modern science can be regarded

as simply another such knowledge system (Watson-Verran and Turnbull 1995). In a series of important ethnographic studies on "everyday mathematics," social anthropologist Jean Lave made clear that cognition takes place in quotidian practices (Lave 1988; Lave and Wenger 1991; Chaiklin and Lave 1993).

All these various strands of scholarship brought about a sea change in the history of pre-industrial science because they validated the study of knowledge systems and practitioners who could not be fit into a linear teleological history of the development of modern science. The idea that the history of science did not have to take as its task the explanation of how the present day state of scientific knowledge emerged has resulted since the early 1980s in a significant change in the conception of the goals of the history of science, which came to include the history of "dead ends" such as alchemy and astrology, of ignorance, and of the knowledge systems of artisans and practitioners (Smith 2009).

Two further developments in the study of science, technology, and medicine have brought forth more intensive explorations of craft knowledge. The first occurred during the 1980s in several different centers, including Paris, Edinburgh, and various universities in the UK, when sociologists of knowledge began to focus on the social construction of scientific knowledge (abbreviated SSK) (Golinski 2005). Their research included some exploration of laboratory work, including the relationship between technique and theory, and the role of lab technicians and their bodily knowledge in the scientific enterprise, but this was generally not their primary focus. Nevertheless, this work helped inspire a study of the ways in which bodily "gestural knowledge" (influenced also by the work of François Sigaut) played a crucial role in historical scientific experiments (Sibum 2000; Chang 2011; Fors et al. 2016). Meanwhile, in *Personal Knowledge*, chemist and philosopher Michael Polanyi (1891–1976) focused explicitly on bodily and tacit knowledge in the natural sciences (Polanyi 1958; Collins 2010). Informed by this research both on tacit and on gestural knowledge, historians of science began to explore the methodology of recreating scientific experiments in order to better understand their actual historical course. Recently, this method of reconstruction has been extended more broadly to historical experiential knowledge and craft practices (Smith 2012, 2016; Smith et al. 2016; Fors et al. 2016; Taape et al. 2020; Dupré et al. 2020; Making and Knowing Project et).

Artisans and Natural Knowledge

All these developments in the study of scientific knowledge opened the way for the bodily knowledge of craftspeople to be regarded as significant – even central – for the study and understanding of epistemologies of natural knowledge. Roughly from the 1990s, historians of science began to study a very diverse range of practitioners – including craftspeople – who

were not primarily university-trained scholars nor “new experimental philosophers,” but who engaged with nature and natural materials in a great variety of ways, including directly transforming natural materials as a part of a craft or of alchemy, formulating vernacular knowledge systems about natural processes, or calling upon the authority of nature in making claims to certainty. Historians of science who studied this diverse group of largely non-elite practitioners formulated the notions of “makers’ knowledge,” “vernacular science,” and “artisanal epistemology,” expressing thereby a newfound sense that craftspeople possessed a philosophy, a science, or a “knowledge system” (van Berkel 1985; Pérez-Ramos 1988; Egmond 1999; Smith 2004 and 2022; Roberts et al. 2007; Harkness 2007; Long 2011). In contrast to previous understandings of craft, these historians disputed that craft practices were rote and mechanical, arguing instead that craftspeople carried out their techniques in light of a coherent set of principles, but that these principles were often codified in objects, in tools, in rituals, or even in songs, aphorisms, and proverbs – in other words, in types of externalizations of knowledge other than writings.

These historians have, for example, described the vernacular epistemology of midwives (Fissell 2006) and the artisanal epistemology of artists, including painters, sculptors, and metalworkers (Smith 2001, 2004, 2010, 2011). The artisanal epistemology, as contained in preindustrial craft practices, and in the writings of practitioners and their books of recipes, includes artisans’ claims that nature and experience are foundational to their knowledge, with certain or positive knowledge contained in the materials of nature, which must be extracted by the practitioner through bodily struggle (Leong 2018). Their search for knowledge is thus active – knowing is doing. This process of struggle often takes the name of “experience” and is learned and explicated through imitation and replication of natural processes. This imitation of nature produces an effect – an intervention in the material world such as a work of art – which both displays and constitutes knowledge. Bernard Palissy (ca. 1510–ca. 1589), ceramicist and author, laid out such a view explicitly in his writings, calling this knowledge a “philosophy of laborers.” He and other artisans, such as Albrecht Dürer (1471–1528), saw this method of imitating nature as a cognitive process (Lestringant 1992; Smith 2004). Imitation as a mode of gaining knowledge for these artists thus simultaneously constituted an aesthetic striving, an articulation of an artisanal epistemology (sometimes in textual form and sometimes in the material form of made things), an investigation into the properties of natural materials, and, at its most basic and all-encompassing, it was simply a mode of going about skilled work (Smith et al. 2016; Smith 2022).

The artisans’ epistemology emerged in part from their training by apprenticeship in which bodily techniques of observation, imitation, repetition, and active doing were modes of work and knowledge transmission. This epistemology, as articulated in texts, in conversations

with scholars and patrons, and in naturalistic works of art, suggested that direct access to nature was both possible and necessary, that knowledge was gained through bodily engagement with matter, that "scientific" knowledge (in Aristotle's sense of "*scientia*") could be extracted from nature, and that the imitation of nature yielded productive knowledge. The articulation of this epistemology – in part by the artisans themselves and in part by intermediaries such as Theophrastus von Hohenheim, called Paracelsus (1493–1541), and Georgius Agricola (1494–1555) – created an identity through which practitioners could express claims to authority on the basis of their hard-won knowledge of natural processes (Smith 2004, 2014, 2015). The artisanal epistemology thus played an important role in the Scientific Revolution, as, through the articulation of this vernacular epistemology in objects and texts, European artisans in the fifteenth and sixteenth centuries engaged in making direct access to nature and the production of effects count as "*scientia*," that is, as certain, positive knowledge (Smith 2004).

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