Numeric Practices of Coloniality in the Transatlantic World

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Abstract

This article contributes to the studies of Colonial Latin America and Ethnomathematics by analyzing the significance of numeric practices in a turning point of world history: the conquest and colonization efforts of early modern Spain in the Americas. While the Black Legend has underplayed Spain's mathematical and scientific contributions, numbers were central to the transatlantic imperial projects of navigation, warfare, and colonization. This article draws from archival evidence of the mathematic texts and conversation tables (coined as the *Books of Gold and Silver*) in circulation in the early modern Americas, to show how the rates, calculation techniques, and numeric discourse of imperial Spain helped form the transatlantic relationships of power established between Europe and the Americas during the colonial period. An unpublished Spanish-language sonnet from the 17th century is reproduced and translated in order to illustrate the Spanish numeric discourse that praises the infinite art of mathematics that when cultivated in American soil yields fruits and riches for Spain.

Resumen (Español)

Este artículo contribuye al estudio de América Latina Colonial y la Etnomatemática al analizar el significado e importancia históricas del número y de las prácticas numéricas en un momento decisivo de la historia mundial: la conquista y la colonización española durante la modernidad temprana en las Américas. Mientras la Leyenda Negra ha minimizado las contribuciones matemáticas y científicas de España, los números eran centrales a los proyectos imperiales y transatlánticos de la navegación, la guerra, y la colonización. Este artículo utiliza evidencia archivística de los textos matemáticos y las tablas de conversión/reducción (acuñado como los *Libros de Oro y Plata*) en circulación, para mostrar cómo las cifras, los cálculos, y el discurso numérico de España imperial contribuyeron a darle forma a las relaciones de poder transatlánticas entre Europa y las Américas de la época colonial. Un soneto inédito en castellano del siglo XVII se reproduce y se traduce para ilustrar el discurso numérico español que alaba el arte infinito de las matemáticas que, cuando se cultiva en tierra americana, cosecha frutos y riquezas para España.

Keywords Ethnomathematics, Mathematics, coloniality, Colonial Latin America, History of Mathematics, Black Legend, colonial math manuscripts

Palabras claves Las etnomatemáticas, Las matemáticas, La colonialidad, América Latina colonial, La Historia de las Matemáticas, La Leyenda Negra, los manuscritos matemáticos coloniales

Introduction

While mathematics and its applications have oftentimes been considered concrete, exact, and infallible, in some cases they can actually be the most abstract, complicated, culturally-endowed semiotics whose societal implications are highly elusive. This article contributes to the recent efforts to initiate a dialogue regarding this paradox in the hopes of inviting further reflection on numeric practices in their multiple cultural and historical manifestations. Contrary to the Platonic notion of "discovery" numbers are not self-evident manifestations found in nature, but rather cultural products and practices and contextualized within a specific time and place.

In the early modern transatlantic world, Spanish math practices developed within a framework that served the needs of the colonial system. In fact, the Spanish conquest, colonization and imperial ideologies were central to the development of math practices of the time and vice versa. Colonial Spanish texts reveal the ways in which these numeric practices both promoted innovative technology and normative standardization, ultimately indicative of an imperial discourse of wealth, morality, authority, and infallibility.

Drawing from archival research of colonial collections, this article provides new insights on early modern Spanish math practices, outlines general tendencies of Spanish-language accounting manuscripts, and uses unpublished textual evidence to connect numeric practices to the colonizing mission of the Americas. Further research is needed to more fully understand both the societal implications of numeric values assigned and practices established within the colonial system—on both sides of the Atlantic, as well as the specific ways these colonial numeric practices disregarded Indigenous ways of knowing and organizing. Nevertheless, this research brings attention to the ways in which numeric practices and culture influence one another—in this case revealing how mathematics was central to the colonial aims of the Spanish hegemony—and invites us to consider how numeric values and practices might be fundamental to the social hierarchies and organization of our own contemporary societies.

Mathematics: Universal Norm or Cultural Product?

The History of Mathematics (with capital letters) has traditionally portrayed mathematical inquiry from a Platonian perspective that conceives mathematics to be the unveiling of universal descriptors and properties; this historiographical tendency indirectly inserts all mathematical discovery into a grand narrative of Western mathematics, treating this tradition as the sole hegemonic, normative, and canonical authority and thus denying alternative multifaceted, dynamic, and sociohistorical explorations of the role of numeric practices. This history, as presented in a majority of History of Mathematics textbooks, presents mathematical ideas and practices in terms of evolutionism, showing how math has progressed and evolved into the discipline now studied at Western universities. It is not coincidental that the origin of contemporary Western mathematics is contingent upon those "literate," textual math forms found in Mesopotamia, Classic and Hellenistic Greece, India, and China. The chronology continues with the contributions of Islamic-Arabic, renaissance Italian, English, French, and German thinkers, and generally concludes with a discussion of contemporary mathematical thought. Raymond Wilder claims that the History of Mathematics has seen great changes over the years but all its constituting histories are written under the premise that only those contributions that have a direct correlation with the important (and variable) topics of the present are included. The limited scope of The History of Mathematics can be attributed to the following two reasons: 1) in this context "mathematics" refers strictly to those numeric practices pertinent to the Western tradition while excluding alternate cultures of mathematics and 2) The History of Mathematics considers only formal contributions to the discipline (and not the ways in which the discipline interacts with its larger sociohistorical context). In this way The History of Mathematics is limited to presenting the formal, normative, history of Western mathematics, and ironically, not the way in which mathematics (in an inclusive sense) drive history, thus discounting the many mathematics of history.

The lack of interdisciplinary attempts to combine historical and mathematical inquiries stems from the timeless debate regarding the nature of numbers: whether these seemingly simple numeric symbols and their properties are universal entities to be discovered as is in nature or particular manifestations of human invention designed to solve culturally and historically-framed problems. Do mathematical truths reside in the external world, there to be discovered by man, or are they man-made inventions? Does mathematical reality have an existence and validity independent of the human species or is it merely a function of the human nervous system? These questions have inspired a heated and controversial debate amongst mathematicians and philosophers of numerous times and places, which can be exemplified in the opposing philosophies of Aristotle and Plato. As an externalist Plato viewed mathematics as a set of logical truths in a timeless space, outside of mankind, and left to be discovered. As an internalist Aristotle embraced an interdisciplinary approach to mathematics that linked this cultural product to its surrounding societal values and organization. This same debate has circulated amongst those mathematicians that believe numbers are found either "inside" or "outside" the human mind.[1]

In his article entitled "The Locus of Mathematical Reality" Leslie White uses Durkheim's discussion of the relation between "collective consciousness" (i.e. culture) and the human mind, to demonstrate that since mathematics is both outside "man" (conceived as the individual organism) and inside "man" (conceived as the human species), it can be located in no place other than culture—culture being both a man-made construct as well as a mode of life informing all human action: "Mathematical realities thus have an existence independent of the individual mind, but are wholly dependent upon the mind of the species. . . Mathematics is a part of *culture*, nothing more" (White, 1947, p. 291).

The official, normative history of mathematics remained unchallenged for the most part until the 20th century when cultural studies emerged and scholars began to conceive mathematics within its larger context. Paulus Gerdes attributes the origins of this project to the French psychologist Georges-Henri Luquet (1929) who explored the social origins of mathematics and the German mathematician, ethnologist, and pedagogue E. Fettweis who had reflected extensively on early mathematical thinking (Gerdes, 1995, p. 19). In 1938 O'Raum is credited with being the first scholar to challenge the colonial aims and legacy of math education in Africa (particularly South Africa and current-day Tanzania), proposing a new model of arithmetic based on the students' cultural context and knowledge base. The scholars Raymond Wilder and Leslie White shared a concern with the anthropological explorations of math and the

[1] White (1947, p. 290) quotes the mathematicians that he considers externalists: "I believe that mathematical reality lies outside us, and that our function is to discover or observe it" (G. H. Hardy)… "In the pure mathematics we contemplate absolute truths which existed in the divine mind before the morning stars sang together, and which will continue to exist there when the last of their radiant host shall have fallen from heaven" (Edward Everett) and those he considers internalists: "mathematics is a human invention" (P. W. Bridgman), "we have overcome the notion that mathematical truths have an existence independent and apart from our own minds" (Edward Kasner and James Newman).

internalist/externalist debate as discussed above. The mathematician Morris Kline was also one of the initial scholars to establish the connection between math and culture in his 1953 work *Mathematics in Western Culture*, soon followed by *Mathematics: A Cultural Approach* (1962) which expanded mathematics history to include both Western and non-Western cultural groups and methods. These isolated attempts blossomed into a collaborative movement to consider mathematics and its relationship to diverse cultures, or *ethnomathematics*. *Ethnomathematics* originally fostered two scholarly trends: a) the investigation of math practices as cultural constructs of "other" societies (as opposed in some way to "Western academic mathematics" and b) the political discussions of mathematics pedagogy, autonomy, and implementation in different academic and intellectual contexts. *Ethnomathematics*, however, divides the field thematically and geographically as opposed to historically; in this way the relationship between math and culture has been considered in distinct social settings such as the workplace, daily life, the classroom, recreation, etc., and in distinct ethnic, cultural, or regional settings such as Maya, Inca, Oceania, Africa, etc., but the role of mathematics in distinct and defining historical moments has not been considered at length.

Historical Narratives of Early Modern Spanish Mathematics

The lack of historical and cultural research of early modern Spanish mathematical texts cannot be attributed to their lack of existence nor significance but rather a combination of factors that have systematically ignored their presence and role in the creation of a modernized, transatlantic world between the Iberian Peninsula and the Americas in the early 16th and 17th centuries.[2] To dispel the myth that mathematics only gained centrality in northern European countries during the Renaissance it is necessary to mention the processes that have relegated

[2] Here the "Americas" refers roughly to the "New World" lands brought into European consciousness following transatlantic voyage and are inclusive of North, Central, and South America.

Spain's mathematical prominence and contribution to the envisioning of a modernized Western math tradition. This debate has been explored thoroughly elsewhere, oftentimes by historians of science, whose work considers the historicizing of both scientific and mathematical development (see Barrera-Osorio, Lopez-Piñero, Navarra-Brotons and Eamon, etc). These scholars mention the stereotype that Spain has received as a "backward" nation focused on re-conquest inquisition and nationalistic propaganda as diametrically opposed to any genuine scientific and mathematic inquiry; the two forces of the so-called "polemic of Spanish science" that have traditionally excluded Spain from discussions of early modern science, mathematics, and technology can be identified as the Black Legend and the "Spanish character" (Navarra Brotóns and Eamon, 2007, p. 10).

The Black Legend was coined by Julián Juderías in 1914 to describe the stereotype that has persistently characterized Spain as "ignorant, fanatical, and backward" (Juderías, 1997, p. 24, and Navarra Brotóns and Eamon, 2007, p. 9). This traditional paradigm that stems from the 18th century discredits Spain's contribution to the modernizing project and even proclaims it to be the antithesis of modernity. José María Lopez Piñero considers Spain's methods "traditional" instead of "modern" because of their theoretical connection to disciplines formed in classical antiquity (like mathematics and cosmography), their high level of description and focus on natural history (as opposed to a development of more rigorous empirical methods), and their philosophy tied to metaphysics and even theology (Lopez Piñero, 1979, p. 47). The Black Legend, however, positions Spain in an inferior position compared to subsequent scientific revolutions throughout Europe instead of recognizing its significant advances at a pivotal moment in world history. Walter Mignolo identifies the "imperial difference" as responsible for elevating the imperial powers of the "second modernity" (England, France, and Germany) over those of the "first modernity" (Spain and Portugal): "the imperial difference initiated by the Reform, gained form in the 17th century in the development of science and philosophy, in the concept of Reason that gave coherency to the discourse of the second modernity (the ascent of England, France, and Germany)" (Mignolo, 2000, p. 78).

The terms generally attributed to the study of early modern European science (renaissance, humanism, scientific revolution, etc.) were developed in the context of alternative European realities, making it debatable whether or not they can be used to describe the "Spanish character." Spain's nationalist agenda instigated by the Catholic monarchs King Ferdinand II and Queen Isabella I appears at odds with a liberal, revolutionary, and scientific discourse. The efforts to advance a national Catholic discourse limited Spain's scientific and mathematic development on two levels: by excluding non-Catholic scientific thought from the national history and by restricting the exchange of information between Spain and the rest of Europe. Even though the 16th century brought about translations of classic scientific and mathematic texts in Spain, Spain's *Edict of Expulsion* brought about the exile of the moor populations thus greatly limited access to the rich Arabic intellectual tradition that had been developed in southern Spain. Language and cultural barriers continued to prevent Arabic contributions in mathematics from being recognized as part of the national Spanish history. Similarly, Felipe II's prohibition of Spanish naturals from studying in universities outside of Spain, pronounced in 1559, limited the intellectual exchange permitted outside of Spain's borders. The Spanish emphasize placed on reading and publishing in the vernacular as opposed to Latin, Greek, or English (Vincente Maroto and M. E. Piñeiro, 1991, p. 80) was an additional factor that limited Spain's insertion into a broader European history of science and math.

The effort to deconstruct the Black Legend artifice and include the Iberian world in the history of early modern science and math is a project that has received much attention and generated substantial research in recent years. The collection of studies *Beyond the Black Legend: Spain and the Scientific Revolution* most directly treats this academic polemic and unites the conference proceedings of a meeting held in Valencia in September 2005 whose objective was "to move the historiography of the Scientific Revolution <<beyond the Black Legend>> and to encourage a more balanced assessment of Iberia's role in the history of early modern science. The conference aimed to test and challenge current interpretations of the Scientific Revolution, and to pose the more fundamental question of whether or not an account of the 'Scientific Revolution' and the origins of modernity that omits Iberian science can have any meaning at all" (Navarra Brotóns and Eamon, 2007). The authors of this collection identify Spain as the greatest empire and power in early modern Europe, making it counter-intuitive that Spain's science would have played such a downcast role as implied by the Black Legend. Postcolonial theorists have pushed the argument even further and argued that modernity was truly born in 1492 (Dussel, 2000, p. 50) and emerged from the first transatlantic relations. In this sense, Spain's centrality in the Atlantic (and now global) sphere (as opposed to the Mediterranean) positioned Spain in a predominate position of intellectual development, innovation and modernity. This not only supposes the importance of Spain in early modern processes but also that of the Americas. If science and math are to be connected to the early modern period, such an analysis must necessarily include a discussion of those scientific and mathematical practices on both sides of the Atlantic as processes that are part of a larger transatlantic framework.

In addition to analyzing early modern math within its early modern historical context, it is also necessary to recognize collective or institutional efforts in addition to individual "discovery." The History of Mathematics and Science has the tendency to exalt certain individuals as beholders of all innovation and expertise while disregarding that the "individual is merely the nueral [*sic*] medium in which the 'culture' of ideas grows" (White, 1947, p. 298); although Spain did indeed initiate many significant projects that changed intellectual traditions their lack of elevated individual theoretical scientists or mathematicians has erased their presence and prominence in the history of Renaissance enlightenment, thought, and scientific innovation. Spain's lack of scientists and mathematicians of fame similar to that of Galileo, Kepler, Descartes, or Leibniz undermines the collective projects accomplished in Spain (as well as the Spanish colonies). For example, the first transatlantic scientific expedition has been attributed to Spain; this project organized by Francisco Hernandez (1570-1577) examined the natural history of Mexico and served as a model for future expeditions. Spain should also be recognized for introducing the departments of Anatomy (in 1555), Surgery (in 1556), and Medical Botany (in 1573) to its universities and founding the Academy of Mathematics in Madrid in 1582 (Lopez Piñero, 1979, p. 93). The Spanish colonies in the Americas were the first to establish a printing press and publish mathematics books in the Americas—over a century and a half earlier than English colonies (Sandifer, 2002, p. 267).[3] It is important to examine these scientific and mathematical contributions as they oftentimes served as models for subsequent efforts of other European countries (Barrera-Osorio, 2006). The scientific and mathematic innovation fostered in

[3] Sandifer identifies the first Spanish-language math text to be the *Sumario Compendioso* (Juan Diez Freyle, 1556) and the first English-language text to be either *The Young Secretary's Guide* (John Hill, 1703), *Hodder's Arithmetick* (1719), or *A course of philosophical lectures. . . illustrating and confirming Sir Isaac Newton's laws of matter and motion* (Isaac Greenwood, 1726).

Spain in the early modern period comes from its unprecedented transatlantic context that required new technologies.

Mathematics as Necessary for Technology

The use of numbers to solve problems stems precisely from their confounding level of abstraction; the abstraction process of representing reality with concrete, numeric symbols has much potential to transform that same reality. Consider the following scenario. A man is cast in the middle of a forest and instructed to transform his unsuitable, challenging environment into a habitable dwelling. His most immediate, tangible tool to begin this task are his own hands which he uses to gather the fallen twigs and brush to create a stronghold. He realizes the shelter could be strengthened against the elements by using the larger logs his hands cannot fell and resorts to an initial level of *qualitative abstraction*. In this stage of abstraction the man envisions the qualitative attributes of a tool that could be used to cut the lumber (i.e. saw). After imaging and securing this tool he can cut and stack larger timber, but still in rudimentary fashion. The logs soon topple and the man is invited to reflect on his task in an even more abstract fashion—he must transform the cylindrical solids into stackable building pieces to ensure a tight fit and stability. In order to do so he resorts to a domain of higher *quantitative abstraction* with increased transformative potential: mathematics. In the depths of his mind the untamed wilderness is reduced to a set of blue prints, centered on a coordinate plan with a standardized grid of measurements and precise cuts. Imposing this numerical, abstract, arbitrarily-constructed domain of concrete, precise, rigorous measurements allows the man to finally construct a dwelling able to withstand adverse elements. That which was closest and most tangible to the man (his hands) alone proved ineffective in transforming his environment. The first level of *qualitative abstraction* (the envisioning of a saw) is a discursive technique associated with language that ascertains the utility of an object with qualitative attributes reflective of one's environment thus only slightly separating one from his environment and transforming nature in a somewhat more effective way. Recourse to the highest level of *quantitative abstraction* (mathematics) places the whole of reality on an alternate domain where nature can be measured, standardized, controlled, and manipulated in an unprecedented fashion, translating into one of the most effective transformative tools of mankind.

Oftentimes the transformative power of numbers, nonetheless, is limited to a discussion of its association with technology; in the case of Spanish conquest and imperial expansion, numeric practices are most commonly examined within the positive connotations of technology, possibility, superiority, and power. The few scholars to analyze the mathematical contributions of early modern Spain focus on those technologies central to Spain's conquering mission: the numerically-based practices of navigation, cosmography, artillery and warfare, architecture, and applied geometry. Ensuring a safe and efficient transatlantic voyage had economic implications (in terms of both material resources and human labor) and contention over Atlantic waters between the imperial powers of Spain, Portugal, Holland, and England inspired further development of sailing technologies. Spain's mission of imperial expansion required extensive maps, precise astronomical instruments and ship captains with sufficient scientific preparation to correctly interpret and use these devices of navigation. These tasks were originally overseen by the *Casa de Contratación* in Seville until Felipe II created the Mathematics Academy in 1582; this academy provided cosmographers with a background in mathematics, astronomy, navigation and their respective tools (including the astrolabe, quadrant, planisphere, astronomical ring, level, etc.). One of the few original works published by the Academy in the 16th century[4] highlights some of the scientific components of the Academy: “determining the altitude of the sun and Pole, classes on how to use the instruments necessary for its calculation, construction and use of navigation charts, how to read altitude charts, use of navigational compass, and practical rules about the seas and winds.” [5]

This tendency to connect numbers with superior technology and dominance is perhaps even more evident in the visual representations of the period; the engravings of Johannes Stradanus—characterized as some of the most consequential visual representations of colonial accounts—oftentimes position technology at the forefront of expansion efforts. The frontispiece of the work *Nova Reperta* illustrates this explicit connection between the “New World” (America) and the European inventions, technologies, and tools, used in its “discovery” thereof (see Fig. 1). This encyclopedic frontispiece brings to the forefront many of the inventions depicted in the remaining plates throughout the work, including gunpowder, the printing press, the compass, the clock, stirrups, chemical

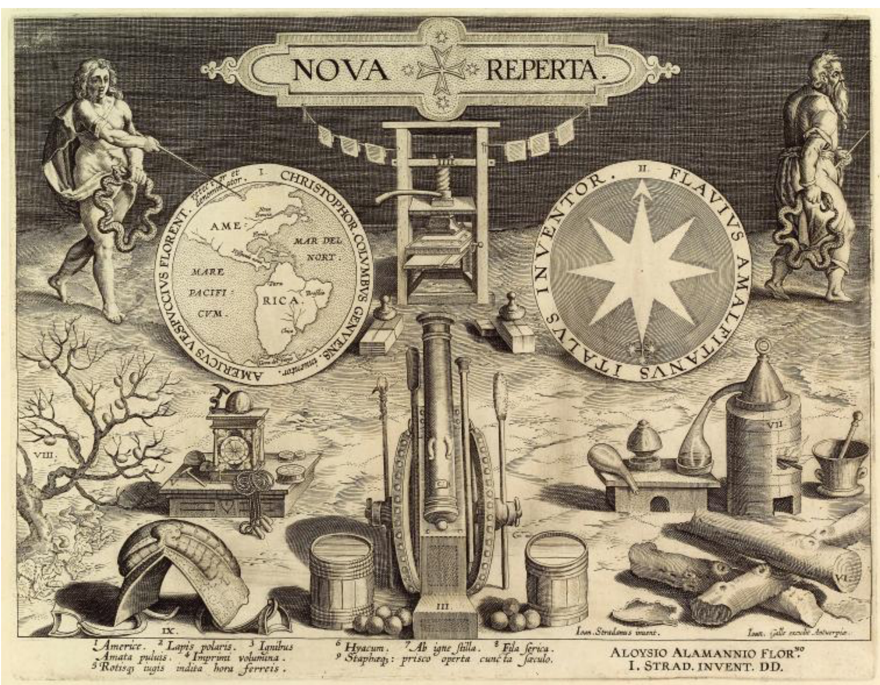

Figure 1: Frontispiece of *Nova Reperta* by Jan Galle after Jan van der Straet. C. 1600.

[4] This work found in the *Biblioteca del Palacio Real* (Madrid) is listed under the title: *comiençase a leer este trattado del SOr. Ju Batta. Lavaña Mathematico del Rey N. S. en la Academia de Madrid a 14 de Março 1588 años. Trattado del arte de Navegar.*
[5] Maroto and Piñeiro, p. 94.

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distillation, the cultivation of silkworms, and the treatment of syphilis with the tropical wood guaiacum. These technological advances are placed in a prominent position, directly connected to the America alluded towards in the background. The connection between European contact with the "New World" and its superior technological and intellectual stance is clearly visible in Stadanus's monumental image of Vespucci's arrival to America: *Allegory of America* (see Fig. 2). In this image, the naked female symbolic of America is awoken from slumber by the firmly positioned European man (in this case Amerigo Vespucci) who comes bearing the Christian cross and the astrolabe, both suggesting a superiority that lies in contrast to the nude primitivism and cannibalistic ritual displayed on the virgin soil of the Americas, devoid of similar technological invention. While the objective is not to justify this interpretation which has been thoroughly debated and deconstructed elsewhere,[6] the image does suggest that these scientific and numeric technologies that appear to facilitate the "discovery" and domination of the New World were not disjoint technological advances imported to the New World but rather developed in conjunction with the Americas and are a *product* (as opposed to a *catalyst*) of transatlantic contact.

Figure 2: *Allegory of America*, Theodor Galle after Johannes Stradanus, c.1619

[6] See Gaudio's *Engraving the Savage*, O'Gorman's *The Invention of America*, and Dussel's *The Invention of the Americas* for a further discussion of the ways in which the European tools and intellect were problematically historicized as superior and able to "discover" native lands and peoples .

Mathematics as Standard of Colonial Organization

Placing these technologies within a context of transatlantic conquest and colonization allows us to consider the role of mathematics in terms beyond those of positive technological development. Establishing a transatlantic network and colonial system between the European imperial powers and the Americas relied heavily on numbers to standardize measurements, values, and geographic coordinates; in this way the number served as a tool of rigid organization. The numeric symbols articulated in Spanish manuscripts and texts established abstract colonial systems that standardized weights, measures, time, space, and value on both sides of the Atlantic. Treatises on trigonometry, the astrolabe, the quadrant and geometry were distributed in order to establish and refine techniques used for the successful measurement of distance, depth, celestial bodies, and prediction of bodies in movement (including enemy lines and weaponry). Arithmetic is perhaps the most circulated math subject of the time—intended to aid with the practice of accounting, calculating taxes, exchanging currencies, assessing profit, and more. In *Instrucción Nautica* Garcia de Palacio used the techniques of modular arithmetic to establish a new system of finding the epact from the "golden number" and determining the date for Easter (declared by the Council of Nicea in 325 to be the "Sunday following the first full moon after the vernal equinox" (Burdick, 2009, p. 89); these mathematical techniques were essential for standardizing the liturgical calendar regardless of geographical location. There was also an attempt to quantify the entirety of the globe in the form of a *mappa mundi* connecting all territories under one unified coordinate plane. In Spain this project known as *relaciones geográficas* was initiated in 1572 by the royal cosmographer Lopez de Velazco but executed with only limited success (Mundy, 1996). The precise and accurate calculation of latitude and longitude was of great importance for navigation and determining land partitions. In 1598 a competition promising a monetary prize worth more than 3,000,000 *maravedis* for the one who could most accurately calculate longitude inspired distinguished mathematicians (including Galileo) to publish their findings (Lopez Piñero, 1979, p. 85); calculating precise lines of longitude had great implications for the Spanish and Portuguese imperial powers who divided their South American possessions on a line of longitude (that, today, still separates the Portuguese-speaking Brazil from the rest of the continent).

Mathematics as Advocate of Imperial Discourse

Because of the centrality of numeric practices in conquest and colonization efforts, there was a conscious effort to portray mathematics positively and promote its use in the printed documents published in early modern Spain, previously dominated by doctrinal, theological, and ethical writings. In the *Sphera del Universo* (1599) Ginés de Rocamora y Torrano advocated for an increased effort to "dominate the science that bears fruit and brings goods, especially mathematics. . . in such a way that after our holy Catholic Faith, there is nothing in this world more true" (Maroto and Piñero, 1991, p. 25). Not only are mathematics true and good but they are precisely that which separate man from animal; in the introductory pages of the *Arismética Práctica y Especulativa del Bachiller* by Juan Pérez de Moya (1562) (which J. M. López Piñero considers to be the most important Spanish math text of the 16th century) a detailed explanation of the rationality mathematics proportions is directed towards the reader: "this here book deals with accounts, that in Latin are called Ratio, for from it man is called a rational animal, he is the only animal amongst animals that knows about counting. . . The virtue of accounting is so innumerable, that only God is he who can finish counting; all other sciences have their certain limits, only this is the one that man calls ration, it has no end. Because this is so clear, wanting to prove it would be like wanting to prove that the sun shines at midday" (Maroto and Piñero, 1991,

p. 20). Mathematics is rational, divine, and above all other sciences. In addition, numbers are able to conserve the peace, and help in learning any other doctrine. In the *Tratado de Mathemáticas* (1573) Juan Pérez de Moya writes "It's a subject that even if it were not as necessary (as everyone thinks) it must be loved, because from it man receives a name distinct from all other irrational animals. It conserves friendship and peace among merchants. It makes those that are slow of understanding in any other doctrine quick and skilled" (Maroto and Piñero, 1991, p. 22). These select examples are not isolated eulogies but reveal the connotations associated to Spanish mathematical discovery and its inextricable connection to a historical context and discourse that seeks to justify, promote, and implement specific numeric methods.

Throughout the centuries mathematics has been both the source of great misunderstanding and awe due to its powerful and transformative level of abstraction. As seen in the previous example, numbers can be attributed technological as well as organizing properties (amongst others). At its most basic level, applied mathematics is the abstract practice of describing real-life concepts and situations in terms of abbreviated variables, transferring this system to an alternate domain, manipulating the variables in order to calculate a solution, and then finally implementing the result in the original realm, thus transforming one's physical reality. Throughout history diverse cultures, generations, and individuals have used numbers (for better or for worse) to transform reality; by conceiving of early modern Spanish mathematics as a product of its transatlantic context we can better understand the ideologies endorsed in the various manifestations of numbers as found in primary historical texts and manuscripts. The ways in which numbers both inspire innovation and transformation as well as implement strict measures of organization in early modern Spain are highly connected to their historical context of transatlantic relations, conquest, and colonization. In this way, when analyzing the numeric clues found throughout colonial chronicles it is necessary to consider them as discursive signifiers linked to the larger discourse surrounding them. In general, the numeric ideology and discourse of the Spanish chronicles of the Indies are characterized by a connection to profit/gain/income, religion/morality, and objectivity/authority/superiority.

Mathematics as Technology, Regulation, and Wealth in the Books of Gold and Silver

Because Spanish math is a product of its transatlantic context it should not come as a surprise that many of the numerically-based texts written in the Spanish language during the 16th and 17th centuries were published in the other side of the Atlantic—in the Americas. Printing presses were established in Mexico in 1539 and Lima, Peru in 1581 and produced a collection of texts oftentimes referred to as the "first mathematical books of the Americas." While the denominator "first" is erroneous as the Indigenous civilizations of the Americas have had a long tradition of advanced mathematics and numeracy,[7] these books did initiate a new stage of math practices and technologies fundamental to organizing Spanish colonies in the New World. While the classification *Books of Gold and Silver* is not a recognized genre of colonial literature, it could be used in this case to refer to the accounting texts printed in Mexico and Peru which are mentioned below.

The first of these books to be published is the *Sumario Compendioso* by Juan Diez Freyle in 1556. This text contains approbatory and introductory pages, chapters of table conversions of various currencies, taxation rates, and sample arithmetic problems that both inform the reader and justify the rates calculated throughout the text, totaling 105 folios. The identity of "Juan Diez

[7] Pre-Columbian texts and archaeological evidence show that the Maya developed a complex numeric system. The Mayan math system was vigesimal and essential for the construction of cities and the organization of communities. For example, the four Mayan Codices that today exist (the Dresden Codex, the Madrid Codex, the Paris Codex, and the Codex of Mexico) contain information about the movement of celestial bodies like the Moon and Venus. Keeping track of the celestial movement was essential for Mayas to organize their calendar and regular activities, such as the preparation of crops for cultivation and harvest season.

Freyle" is highly debated as there seem to be multiple historical figures of this time with the name "Juan Diez/Díaz"; numerous scholars have associated him with the Juan Diez that accompanied Cortes in the conquest of New Spain but Brace Stanley Burdick suggests that this conclusion is unfounded if not erroneous and notes the possibility that the religious surname "Freyle" could have been used as pseudonym to prevent the text from being placed on the Church's list of banned books associated with the unlawful practice of usury (Burdick, 2009, p. 43). It cannot be determined whether or not the author's background was connected to Mexico, Peru, or Spain, but only that he was present in Mexico at the time of publication. The book is primarily directed to a Peruvian readership involved with accounting as indicated on folio 85r (Burdick, 2009, p. 42) and secondly towards a Mexican audience as indicated by the limited discussion of the conversion of the silver peso minted in Mexico City. In this way, this text appears to have more in common with the accounting tables printed in Lima in the 16th and 17th centuries: *Libro General* (1597), *Libro de Plata* (1607), and *Tabla General* (1696).

Because of its primacy the *Sumario Compendioso* has received much scholarly attention and presents unique characteristics that separate it from subsequent accounting manuals published in Mexico in the 17th century including the *Tablas de Reducciones* (1603), *Alivio de Mercaderes* (1610), *Libro de Cuentas* (1615), *Reformación de las Tablas* (1668), *Reducciones de Plata* (1697), and the *Reducción de Oro* (1700).[8] The *Sumario Compendioso* reflects a nascent moment in early American accounting and is unique in that it includes a general treatise on arithmetic and its function along with the conversion tables. These 25 pages of arithmetic rules

[8] These works along with those published in Lima indicated in the previous paragraph come from the bibliographic work of Burdick (2009) and are the most comprehensive collection thus far of known copies of conversion tables printed in the Americas for accountants and merchants dealing with various forms of Spanish and American currencies. It is probable, however, that more titles existed; the Spanish system of granting license rights for printed texts for a determined number of years (generally seven to ten years) allows for the same, or similar, content to be printed periodically and might explain the gap in years observed in the publications mentioned previously and suggest that other unknown titles were also published in the interim.

discuss the solutions to applied word problems including shopping scenarios, taxation due the king, exchanging diverse currencies, valuing goods, finding desired proportions, and paying the church, as well as solutions to theoretical problems involving square and cube roots, fractions, and congruent numbers.

The studies regarding this text are almost entirely focused on the arithmetic methods and mathematical curiosities presented, oftentimes belittling the significance of the "redundant" table material that fills the majority of its pages; this selective analysis reveals the tendency of historians and mathematicians to highlight only those numeric elements important to the historical development of the Western tradition of mathematics focused on arithmetic, algebra, geometry, trigonometry, and calculus. The *Sumario Compendioso* is praised for its role in introducing European mathematical technologies and innovative methods to the Americas. The text does indeed inspire a new spirit of possibilities by outlining the arithmetic methods able to remedy a myriad of real-life problems and situations. On a global scale, these early modern numeric practices can also be considered innovative as they lay the foundation for transatlantic systems of accounting, checks and balances, and taxation operative on both sides of the Atlantic.

It is ironic, however, that while so much attention is given to the few pages of arithmetic problems of the *Sumario Compendioso*, so little (if any) attention is paid to the countless pages of standardizing conversions, measurements, and systems of control proper to the tables of exchange and taxation rates. Perhaps because these tables found in this collection of accounting texts (as opposed to the minimal discussions of pure arithmetic) have not been considered pertinent to the development of the modern-day discipline of (Western) mathematics, their contribution and importance are not acknowledged in the History of Mathematics. For example, when reviewing the *Libro de Plata* (Lima, 1607) one mathematician writes: "Although this is mostly a big book of tables, there are a few interesting things about it" (Sandifer, 2002, p. 272). This condescending attitude towards the numeric tables of the *Books of Gold and Silver* generally prevents the possibility of re-printing these texts as facsimiles available to a larger, contemporary readership. Those interested in the organizing structures implemented by these numeric accounting tables are faced with the arduous task of accessing colonial archives in order to review the descriptive material contained in the accounting texts along with their conversion tables. Such archival efforts have the potential, nonetheless, to initiate a conversation about the cultural and historical implications of the number in the early modern Spanish context of conquest technology and colonizing standardization. A review of the numbers in the *Books of Gold and Silver* suggests that: a) the math techniques developed therein are the *product* of a newly established transatlantic context in which the Americas participated, b) the accounting techniques, practices, and rates outlined within regulated many of the economic terms of this transatlantic (and colonial) relationship, and c) the numeric practices therein were connected to a Spanish imperial discourse.

These generalizations do not presume to apply in all cases nor bring closure to the case of these early modern accounting texts but rather invite further reflection and dialogue regarding the role of the number in Spanish colonies and the early modern context at large. Continued archival research is necessary for advancing this objective. A sonnet found on the introductory pages of the *Libro de Plata* (Book of Silver) (Lima, 1607), for example, illustrates the three observations made above, making reference to other archival sources and the larger sociohistorical context of early modern transatlantic accounting and commerce. This poem comes from the print copy housed at the *Biblioteca Nacional* in Lima, Peru and is being reproduced now for the first time. A literal English translation of the poem is provided which preserves most description and imagery but only roughly maintains the syllabic meter and rhyme structure of the original sonnet. This sonnet praises the infinite art of mathematics that when cultivated in American soil yields fruits and riches for Spain; in addition, the literary devices employed by its author place these transatlantic math practices within an imperial discourse of discovery, wealth, and morality.

SONETO
AL AVTOR DESTE
TAN VTIL, QUANTO EXCELENTE TRABAIO.
EL LICENCIADO PEDRO DE O~NA

ESTA Infinita (entre las otras) Arte:
Que tanto el Mathematico venera,
De las de su linaje la primera,
Que dá a Mercurio vida; y fuerza a Marte:
Que suma, y resta, y multiplica, y parte,
Y desnudas sus formas considera:
Nunca su luz tan clara descubriera
En esta Occidental, Indica parte:
Ni el rico humor de aquel granado cerro;
Que siembre en el Callão, todos los años
Los granos, que hazen fertil a Sevilla;
Lográra el fructo, sin notable yerro,
Ni lo dexáran de añublar engaños,
A no salir el sol de Garreguilla.

SONNET
TO THE AUTHOR OF THIS
VERY USEFUL, SO EXCELENT WORK.
THE GRADUATE PEDRO DE O~NA

This infinite (amongst the others) Art:
That the Mathematician so venerates,
From his lineage the first,
That gives Mercury life and force to Mars:
That adds, and subtracts, and multiplies, and divides,
And naked its forms considers:
Never before such a clear light it discovers
In this West, pick a place:
Not even the rich sense of that grand hilltop;
That plants in Callao, every year
Its grains, that make fertile Seville;
Will make fruit, without notable error
Nor stop clouding it with deceit
Until the sun of Garreguilla appears.

The geographic references of this poem include the various American or “New World” locations as central to the Western tradition and mathematical development. The image of the *granado cerro* (grand hilltop) most likely refers to the silver mines of Potosí as these were commonly portrayed in hill-like fashion in colonial chronicles. The mines of Potosí are not only characterized by their elevation but prominence in the silver mining industry during Spanish colonization. Observe the image of Potosí drawn by the Indigenous chronicler Guaman Poma de Ayala (see Fig. 3) who writes that Potosí has “many monasteries, churches, religious, and police, silver as common as stones, gold as dust, without account as those of the Indians do not count into the thousands. Eight *reales* are called a *tomín* in this said city, everything in service of God” (Guaman Poma de Ayala, 1987, p. 1140). These riches were then funneled through the Peruvian port of Callao, one of the largest colonial ports of the Americas (see Fig. 4). Guaman Poma de Ayala describes Callao as the place that sends silver to Castile and receives clothes in return. In addition “From there [Callao] riches are dispatched, riches are drowned. Some leave naked, others very rich, as God grants the luck. Some cry, some sing, others go and come and from this

Figure 3: *Ciudad la Villa rica emperial de Potosí*. Felipe Guaman Poma de Ayala. c. 1615.

said city and port of Callao, rich Seville” (Guaman Poma de Ayala, 1987, p. 1116). With such movement of people, goods, and riches, it comes to no surprise that Callao was a center for commerce and merchants looking to take advantage of the knowledge of accounting and currencies provided in Garreguila’s book of silver. Both cities are central to early modern transatlantic commerce, arithmetic, and accounting and are included *en esta occidental* (in this West)—a critical geopolitical distinction between the (Western) transatlantic territories that exchange goods, capital, and ideas and those African and Asian territories that do not (Mignolo, 2000).

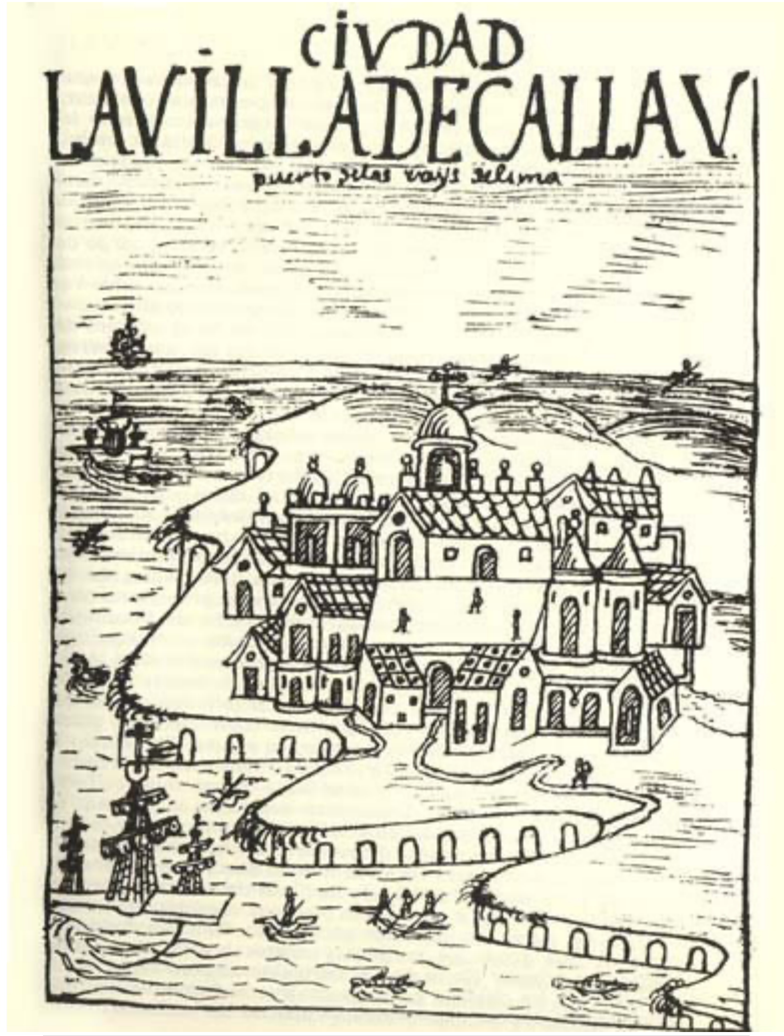

Figure 4: *Ciudad la Villa de Calloa*. Felipe Guaman Poma de Ayala. c. 1615.

It is difficult, however, to highlight America’s inclusion in the newly extended Western hemisphere without also analyzing its role within the newly established transatlantic relationship of *coloniality*;[9] the Americas were inserted into the Western world under the premise that their

[9] Aníbal Quijano has coined the term *coloniality of power* to describe the social, cultural, racial, and economic hierarchies created between imperial powers and colonial “others” in the Atlantic commercial circuit that have privileged colonial discourse and denied alternative cultural semiosis.

colonies would provide for the colonial powers, in this case the Spanish monarchy. A discussion of the commercial activity of Callao cannot avoid mention of the city on the other side of the transatlantic trade network—that of Seville. Prior to Spain's contact with the Americas, Spain was periphery to the Mediterranean world but upon contact Spain, more specifically Seville, became central to a newly defined transatlantic western world. This important European port was a receiving point of people, goods, riches, and reports coming from the colonies, and centrally located at the *Casa de Contratación*. Of interest, however, is the precise nature of the transatlantic relationship—the Americas sustain Spain. Referring back to Guaman Poma's image of Potosí, the columns extending from the rich hilltop mine are shown to be supporting a Spanish shield and the title of the image identifies the mine as the foundation for Spain's religious and political world domination: "CITY / THE RICH EMPERIAL CITY of Potosí. Because of the said mine is Castile, Rome is Rome, the pope is pope and the king is monarch of the word. . . . / PLVS VLTRA / EGO FVLCIO CVLLVNAS EIOS [latin: I fortify its columns]" (Guaman Poma de Ayala, 1987, p. 1140). Not only do *los granos* (or coins) of the American colonies *hazen fertil a Sevilla* (make Seville fertile) and enrich their European colonizers, but numbers are used to create a global economy (of modernity) that favors Spain and disadvantages the Americas. The author of the colonial merchant guide Tomás Mercado notes that (although against Catholic principles) gold and silver were worth minimal value in Peru but exponentially acquired value upon arriving in Spain; in this way the price of these metals changed as they traveled across the Atlantic even though the quality of their substance remained the same. This arbitrary process of establishing prices is moralized, naturalized, and institutionalized, however, the Spanish imperial discourse describes this process in terms of a "*el precio justo*" (the just price) (de Mercado, 1569, p. 13b) that controls colonial resources and relations.

Finally, the literary devices, images, and narrative voice of this sonnet associate mathematics with a moralizing discourse of religion, wealth, and power that justify those numerically significant transatlantic and colonial relationships. The descriptive attributes of mathematics as *infinita* (infinite)*, sol* (sun)*,* and *desnudas* (naked) insert the practice within a divine context of unbounded limits, truth, and purity. This art is connected in a direct blood-line *linaje* (lineage) with the other Arts of the time (theology, grammar, etc.) and is "venerated" by its practitioners/mathematicians (in the same way a believer might revere his religion). Nonetheless, this mathematical art is *la primera* (the first) to transform the cosmos by "giving Mercury life and force to Mars" thus incorporating mathematics into the Western cosmology where it can be used to contemplate the heavens without fear of idolatry. The selection of planetary masses is not arbitrary; while *Marte* (Mars) forms a consonant rhyme pair with *parte* (place)*, dá a Mercurio vida* (giving Mercury life) is a double entendre whose more subtle meaning is that of the alchemic procedure that uses *mercurio* (mercury) in order to process the silver of Potosí, an innovation created in the context of the Americas and central to the economic *vida* (life) of the colonies. The polysyndeton "adds, and subtracts, and multiplies, and divides" and the epithet "clear light" reiterate the numerous functions of mathematics and their illustrative clarity/infallibility—these numeric practices being powerful enough to connect them with the act of "discovery," a concept which can both refer to the Aristotelian base of mathematics as inherit to nature and "discoverable" (as opposed to the Platonian notion of mathematics as man-made invention) and to the imperial discourse of Spanish "discovery" of the "New World." The discovery motif along with the paradise motif invoked in the concluding tercet of the sonnet (through the imagery of "fruit" "without deceit") are very common literary themes found throughout colonial Spanish chronicles; both are common discursive techniques employed with the objective of both justifying Spain's unbridled acquisition of New World resources and riches and promoting further inhabitance and systems of control of this environment portrayed as natural, primitive, and plentiful. The theme particular to this sonnet—agricultural growth—(invoked by the imagery of "light," "sun," "planting," *granos* or grains, "life," "force," lineage," "fruit," etc.) places the transatlantic colonial relationship between Spain and Peru made possible by the "sun of Garreguila" (i.e. the accounting manual itself) in positive, moralizing terms thus justifying Spain's imperial mission of wealth; paradoxically, however, in this relationship of *coloniality* the numbers that attribute value, define space, and quantify reality on each side of the Atlantic do not add up equally for each side of the transaction.

One of the characteristics of human societies is an effort to explain and control their surroundings; in the case of early modern Spain, a series of scientific and mathematical technologies and innovations were necessary for strategically positioning this new world power in a position of control over transatlantic relations. Spain's cultivation of math and science is intrinsically connected to its connections to the origins of modernity which required "tasks such as the unification of coins and measures or the investigation and control of human behavior that acquired political relevance, becoming itself into an instrument at the service of the State" (Lopez Piñero, 1979, p. 92). Spain's Golden Age proclaims a spirit of progress that surpasses classical models, "discovers" "New Worlds" and acquires infinite riches made possible through the development of new technology. This progress, however, must be considered alongside the strict mathematical models that measured time, space, and value along imperial designs and colonial structures. Understanding the technologies, organizations, and discourses surrounding the number in early modern, transatlantic, colonial Spain has great potential for transforming the way in which we perceive our own modern, globalized, and neocolonial world.

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