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Jack Williams

Robert Recorde

Tudor Polymath, Expositor and Practitioner of Computation

Springer

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Foreword: Robert Recorde and the History of Computing

John V. Tucker

Robert Recorde was born *c*.1510 in the port of Tenby, in west Wales, and he died in in Southwark, just south of the Thames, in the summer of 1558. Recorde lived through the tumultuous reigns of Henry VIII, Edward VI and Mary; Elizabeth I was crowned 6 months after Recorde's death. Jack Williams' monograph examines the historical evidence and scholarship we have on Recorde and gives us an excellent account of what is known of his life and times. Such a scholarly study has been long awaited. At last, we have *terra firma* on which to base all sorts of historical studies involving Recorde and his achievements.

One such study is the history of computing. I am a computer scientist interested in the history of computing, which I view as a new field within the discipline of history of science and technology. My interest in Recorde, and his European contemporaries writing on practical mathematics, arose from my curiosity about the history of data. In my lectures on the history of computation I wanted to explore the development of

(i) quantification and measurement;
(ii) *data and computation;* and
(iii) *technical education*.

I found these topics played a significant role in the history of computation and, indeed, in the history of science and technology generally. However, I also found they seem to be neglected in the history of computation and marginal in the history of science and technology. Recorde is a particularly important representative of European writers on mathematical sciences in the Early Modern period. I hope we will see increased scholarly interest in Recorde and his contemporaries, including further volumes on the period in this Springer series on the History of Computation.

J.V. Tucker
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Jack Williams' book is biographical and would be at home among works on the history of mathematics, education, currency, or the Tudor world in general. In this foreword I will explain why it is natural to welcome this invaluable work into our series on the History of Computing. We are grateful to Jack Williams for enabling us to broaden our coverage by introducing biography and a new period.

Recorde's Books

Recorde was a scholar and polymath, active in several fields and professions. He is remembered because of his mathematical works, which form a programme of instruction in English designed to teach some advanced ideas to a broad audience. Here is a summary of the four extant books[1]:

The Grounde of Artes

A first edition appeared circa 1543. It is a commercial arithmetic and covered arithmetic with pen, counters and fingers. Computations involve only natural numbers. It was long thought to be the earliest surviving mathematical work in English to introduce the Hindu-Arabic numbers.[2] New editions followed in 1549 and 1550 and an edition of 1552 added fractions and alligation. Over 40 editions followed over 150 years, the last in 1699 when pages about the abacus were omitted.

The Pathway to Knowledge

The first edition appeared in 1551. It is an introduction to geometry, the first in English. It simplifies material from the first four books of Euclid, which are about plane geometry, with a view to applications.[3]

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[1] Fortunately, all four books are readily available in facsimile as follows:

Recorde R (2009) The Grounde of Artes 1543. Renascent Books, Derby
Recorde R (2009) Pathway to knowledge 1551. Renascent Books, Derby
Recorde R (2009) The castle of knowledge 1556. Renascent Books, Derby
Recorde R (2010) The Whetstone of Witte 1557. Renascent Books, Derby

[2] An earlier anonymous text surfaced at auction in 2005; it is published in facsimilie, *An Introduction 1539*, Renascent Books, Derby, 2009. Of course, Hindu-Arabic numbers were to be seen earlier. In St Mary's Church, Tenby, the date 1496 is in stone relief, close to a memorial to Recorde.

[3] The first complete English translation of Euclid was Henry Billingsley's Euclid of 1570.

The Castle of Knowledge

The first edition appeared in 1556. It is an introduction to astronomy, the first in English. It covers Ptolemy's sphere and mentions Copernicus's new (1543) theory.

The Whetstone of Witte

The first edition appeared in 1557, intended as a companion to the *The Grounde of Artes*. It is an introduction to algebra, the first in English. The algebra is in the German cossick tradition. It covers roots, equations and surds. It introduces the equals sign.

Recorde is commonly mentioned but rarely celebrated in histories of mathematics, which are dominated by the technical development of pure mathematics. He founded modern mathematics in the British Isles with a grand exposition of mathematical thought in which numbers are abstract and arguments are important. But his works are expository; they are directed toward practical activities that are ignored in pure mathematics; and they are based on advanced scholarship rather than original discoveries. Their detachment from the academic mathematical tradition began in Recorde's lifetime. To appreciate Recorde one needs to be interested in more than the technicalities of pure mathematics.[4] One needs to be interested in the *reflexive relationship between mathematics and the world's work.*

The view of Recorde from the perspective of computing is different from that of mathematics. Computing is fundamentally a mathematical science that is *intimate* with the world's work because computing is largely about collecting, analysing and creating data. Thus, if we are to seek the origins of computing, we must think about *quantification, measurement* and *data*. To be concrete, one need only ask a simple question such as:

> When, how and why did the Hindu-Arabic numbers, with their purely symbolic data representations and algorithms, develop and become standard in a country?

Data connects computing directly with knowledge, expertise and professional practice. In the history of computing, if we follow the data, we are led to Recorde and his many European contemporaries. The growing awareness of quantification and data in the Tudor period led to new conceptions of knowledge and science, and to the education of people in the ways of mathematics. Quantification, data and computation played a truly significant role in the undisputed cultural transformations of the sixteenth and seventeenth centuries.

[4] For a portrait of the mathematics of the period see Stedall JA (2002) A discourse concerning algebra: English algebra to 1685. Oxford University Press, Oxford

Commerce and the Rise of Computation

The sixteenth century saw trade in new international markets and products; increasing dissemination of information through printing; an increase in travel and the development of international networks; and a growing reliance on technical and expert knowledge in practical activities. European society and economy was becoming dependent on measurement and calculation in its organization and activities. The collection and use of data was reshaping the way in which knowledge and money were employed and distributed in Europe.

The origin of these innovations was Italy, from where they spread to Germany, the Low Countries, France and the British Isles.[5] From the fourteenth century, Italy had developed international banks; financial and accounting services; schools for calculation and universities; and printing presses. Italian business was trusting of the data and computation and so the conduct of business was becoming increasingly abstract.

The mathematical tradition at the beginning of the sixteenth century was surveyed by Luca Pacioli (1445–1517) in his great work *Summa de arithmetica, geometria, proportioni et proportionalita* (Venice, 1494, second edition 1523). Written in Italian, not Latin, it covered arithmetic; elements of algebra; tables of monies and weights; double-entry bookkeeping; and Euclidean geometry.

Thus, computation for commercial purposes was essential in Italian commerce. It was taught in schools to 8–10 year old children by *maestri d'abbaco* and led to a vernacular manuscript and book tradition called *Libri d'abbaco* – the so called *abbacus texts*.[6] Now it is important to note that the abbacus texts have nothing to do with the abacus; the word "abbacus" has been taken from the Italian name of the tradition. The abbacus texts have been studied in depth by Warren van Egmond who has revealed the nature of this important mathematical tradition.[7] Abbacus texts use Hindu-Arabic number systems only and modern methods of calculation; there are large collections of sample problems and wide varieties of problems; practical situations are used as exemplars; there are meticulous step-by-step explanations; and algebraic methods are introduced.

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[5] For example, in the case of Germany, one thinks of works by Johannes Widmann (*c.* 1462–1498), Gregor Reisch (*c.* 1467–1525), Jacob Köbel (1470–1533), Michael Stifel (1487–1567), Adam Riese (1492–1559) and Christoff Rudolff (1499–1545).

[6] The tradition descends from Leonardo of Pisa's *Liber abbaci*, 1202, with its origins in the medieval Arab world; see Sigler LW (2002) Fibonacci's Liber Abaci. Springer, New York.

[7] For an excellent short introduction see Van Egmond W (1994) Abbacus arithmetic. In Grattan-Guinness I (ed) Companion encyclopedia of the history and philosophy of the mathematical sciences. Routledge, London, vol 1, pp 200–209. His indispensible scholarly account of the abbacus tradition is Warren Van Egmond, *Practical Mathematics in the Italian Renaissance: a Catalog of Italian Abbacus Manuscripts and Printed Books to 1600*, Istituto e Museo di Storia della Scienza, Florence, 1980. English translations of abbacus texts are: D E. Smith's translation of the Treviso Arithmetic of 1478 in Frank J. Swetz, *Capitalism and Arithmetic*: *the New Math of the Fifteenth Century*, Open Court, La Salle IL, 1987 and, more recently, Jens HØyrup, *Jacopo da Firenze's Tractatus Algorismi and Early Italian Abbacus Culture*, Birkhäuser, Basel, 2007.

The abbacus texts and schools are important for the history of computation. First, they improved the Hindu-Arabic number system and calculation methods to meet Western needs, providing a basis for our modern symbolic rule-based methods. Second, the abbacus texts and schools helped to change the conduct of business in Europe by introducing and embedding mathematics into commerce and society. Third, they influenced the development of algebra because the concrete practical problems cried out for general abstract algebraic methods.[8]

Quantification and New Knowledge

Reading the texts it is evident that Recorde offered his readers a vision of knowledge that had these characteristics:

- Knowledge is broadly and practically conceived and includes commerce, land surveying and navigation.
- Knowledge is precise and quantitative.
- Knowledge is firmly based upon sound reasoning that must be open to demonstration and debate.
- Arithmetic and geometry are a foundation for knowledge.

One well-known quotation that reflects Recorde's attitude to the nature of knowledge and authority is this:

> … yet muste you and all men take heed, that … in al mennes workes, you be not abused by their autoritye, but euermore attend to their reasons, and examine them well, euer regarding more what is saide, and how it is proued, then who saieth it: for autoritie often times deceaueth many menne … [9]

Recorde is introducing the Tudor reader not just to mathematical methods but to a new *mathematical frame of mind* and a new idea of what constitutes knowledge.

Recorde and his contemporaries are prominent in all sorts of historical topics of which I will mention two relevant to the history of computation, namely: the origins and development of science, and the rise of Europe.

The origins of the scientific method, and the purpose of science within society, has long exercised scientists, philosophers and historians, who have their own reasons (and audiences) for their investigations. For example, many historians are vexed by the notion of scientific revolution, though the notion continues to be popular among scientists, who commonly use it to magnify the work of Galileo and Newton.

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[8] Italian mathematicians who are important in the history of algebra, such as Niccolo Tartaglia (c.1499–1557), Girolamo Cardano (1501–1576), Lodovico Ferrari (1522–1565) and Rafael Bombelli (1526–1572), were influenced by these problems.

[9] The quotation is a part of Recorde's comments on Ptolemy in *The Castle of Knowledge 1556*, Renascent Books, Derby, 2009, p. 127. It is carved into the *Robert Recorde Memorial* at the Department of Computer Science, Swansea University, which was designed by John Howes and made by Ieuan Rees in 2001.

The origins of the scientific method is the subject of classic studies by Edgar Zilsel of the period 1300–1600. In 'The sociological roots of science' (1942), he observed the following three things relevant to our topic.[10] First, the principles of causal explanation and methodological experimentation derive from the working practices of craftsmen, artisans, surgeons, instrument makers, surveyors, navigators, engineers and architects; this idea is often referred to as *Zilsel's Thesis*. Second, the mathematical description of nature in the seventeenth century depends heavily on the commercially inspired mathematical work of Pacioli, Recorde, Digges, Tartaglia and others. Third, the historical context is the development of capitalism.

Recorde is not alone, of course; his work belongs to a much larger European movement. But it is worth noting that Recorde initiated practical mathematics in a country that was becoming a world power and in which, in the next century were to appear several great landmarks of science, such as the works of Francis Bacon and of Isaac Newton, and the founding of the Royal Society (in 1660).[11]

Our conception of the modern world is fundamentally European. One feature of modernity is quantification, encompassing the systematic collection of measurements, records and other data and their analysis by computation. The historical study of the rise of Europe has led historians of ideas to enter the scholarly world of Recorde and his contemporaries. For example, Alfred W Crosby wanted to understand the success of European imperialism and the dominance of European based societies. In *The Measure of Reality*[12] he formulated the thesis that this success was due to the development by Europeans of the capacity and the mentality both to organize large collections of people and capital, and to exploit physical reality in order to gain knowledge and power. The crucial factors that determine capacity are the administrative, commercial, navigational, industrial and military skills based on measurement and mathematics. For mentality, a new model of reality is required – a quantitative model. Crosby's thesis and arguments depend heavily on the development of practical mathematics.

To test and develop such historical theories we need substantial new scholarship such as that of Jack Williams.

History of Computing

Studies of science and society suggest that there are deep reasons for the ubiquity and influence of modern computing, especially software. Our current craving for data has a long and intriguing history.

[10] Zilsel E (1942) The sociological roots of science. Am J Sociol 47(4):544–562. The article is reprinted along with unpublished material in Edgar Zilsel, *The Social Origins of Modern Science* ed. Diederick Raven, Wolfgang Krohn and Robert S. Cohen, Kluwer, Dordrecht, *c*.2000.

[11] Whilst the significance of Bacon is well established in the orthodox historiography, the influences on Bacon are less clear. Perhaps one can detect an influence of Recorde's writings and connections with Dee, and Dee on Bacon.

[12] Crosby AW (1997) The measure of reality: quantification and Western society, 1250–1600. Cambridge University Press, Cambridge.

At the *technical* heart of the history of computing is data and computation. A computer scientist studies the representation and storage of data; algorithms for transforming data; programming methods for constructing software to represent algorithms; and methods for designing and operating machines and networks of machines to implement software.

The history of computation is founded upon the history of these four topics. And the technical histories of data representations and algorithms span thousands of years, for one only has to study the calculations and reasoning of the Greek mathematicians (such as Euclid, Eratosthenes, …). As suggested earlier, the evolution of number systems lead us directly to questions about science and society.

However, the history of computing is also about civil and military applications; the creation of vast new businesses and organisations; changes in education and skills, and in social and cultural behaviour. The history of computing cannot be a history of technicalities independent of the world. In search of the origins of computing we encounter technical problems to do with data, representations and algorithms that are close to the world's work and for which quantification, measurement, and data, are the conceptual *sine qua non.*

I think interesting material for the history of computing can be found wherever data is collected and computations are made. In our times, we have become addicted to data, which is used to represent the world in ever more detail and has become a commodity. Today, as in Recorde's time, the ultimate weapon for quantification is an ancient data type, that of money.

I think that the story of data has been taken for granted in the history of computing, leading to a concentration upon the technicalities of software and hardware or upon businesses and markets. It is through the history of data that we can develop new and comprehensive approaches to some problems, such as integrating the history of computing into the history of science and technology and, in particular, of creating a social context for explaining the history of software in our museums.

In my view data is the primary concept of computer science so a big question arises: *What are the origins of our use and dependency on data?* In the long search for an answer we encounter Recorde and his world. I invite you to inform yourselves about this world by studying and working with the fascinating fruits of Jack Williams' research.

Preface

Interest in the life and works of Robert Recorde has persisted at a low and unobtrusive level during the past century, as will be seen from the Select Bibliography appended. Of the two of works that deal with the broad sweep of Recorde's life, Kaplan's unpublished thesis is the most comprehensive. The remaining publications concern themselves with specific aspects of his books. His contribution to the teaching and the understanding of arithmetic, geometry and astronomy received the most attention which is both deserved and necessary, for Recorde's avowed aim in writing his books in English was to facilitate self-education in these three subjects. There is general agreement that this constituted a seminal contribution for which he should be remembered. His activities as a servant of the Crown concerned with the minting of money and with the mining of silver have been examined only patchily. The article by Clarke on Recorde's mining activities in Ireland is now nearly a century old and needs revision in the light of both new evidence and other evidence, available at the time but which was not taken into account. The two articles relating to Mint matters remain authoritative, but both need to be placed in the context of information relating to Recorde's dispute with the Earl of Pembroke, newly uncovered. Easton's papers on Recorde's Arithmetic and Geometry also remain authoritative, but in both cases deliberately forewent any search for possible sources of his material. This deficit will be addressed. The publications that deal with his Astronomy concentrate on the question of whether or not Recorde was the first Englishman to embrace Copernicanism. Where Patterson ventures beyond this remit, she perpetuates the shortcomings of Clarke and adds some of her own. There is far more material of substance in the *Castle of Knowledge*, Recorde's largest and most wide-ranging text, than has been examined to date. Hughes' work on aspects of the *Whetstone of Witte* goes a long way to dispel the notion that the only matter worthy of note in this book is the introduction of the equals sign and underlines the need for a broader debate on the nature of Recorde's algebra.

The general impression left by these publications is that Recorde did a good job of writing sound English texts on arithmetic, geometry and astronomy, but showed little in the way of originality other than by introducing the = sign, arguably embraced Copernicanism and maybe introduced algebra into England. In the absence of firm

evidence that he was gaoled for libel, the favoured cause of his imprisonment, perpetuated now for nearly a century and also based only on speculation, was that he was guilty of some form of financial peculation in connection with his activities in Ireland.

There is now documentary evidence concerning the failure of his case of financial irregularities against the Earl of Pembroke and his consignment to prison for inability to pay the fine consequently imposed; this will be presented and analysed. With respect to his activities in Ireland it is clear that failure of the Crown to settle their debts to him bankrupted him but that his family profited from the affair after his death. He was meticulously honest in all his financial dealings.

It is not to be expected that text books intended for self-education at an elementary level would contain evidence of original thought, other than perhaps on matters related to teaching. Nevertheless there is evidence in his texts of a deeper understanding of the subjects he was treating and of his potential for original contribution, had he had time to indulge. Such evidence is only made available by a detailed scrutiny of these texts, which does not make for easy reading. It is primarily to accommodate such material that this book is presented as a set of self-standing essays. To understand the whole man an understanding of the detail in the essays is needed and no apologies for such an approach are offered. Recorde understood and initiated the detail.

Finally there are the topics that have to date only been referred to in passing in published literature on Robert Recorde. He earned his living as a Physician and addressed himself as such. In common with most of his contemporaries in this profession, little is known of their practical activities. As he was neither a member of the Royal College of Physicians nor of the Company of Barber Surgeons his medical activities are possibly even more obscure than most. Kaplan has given some attention to Recorde's book on urology, primarily to expose and discuss an apparent uncritical acceptance by Recorde of the views of historical authorities on the subject. This topic will be re-examined as also will be the methodology advocated by Recorde for the taking and recording of experiential data. Comments on Recorde's antiquarian activities are sparse and scattered. He had a relatively large collection of English manuscripts on a wide range of subjects whose provenance and relevance to his published work will be examined as also his Anglo-Saxon scholarship. These interests brought him into contact with individuals who are recognised as the founders of English antiquarianism.

His interest in languages also bears on his contributions to the vocabulary of English mathematics. So far there have been only piecemeal assessments of his readers and of their reactions to his works. These readers were widely distributed across English society for over a 100 years, extending well into the initiation and extension of the 'Scientific Revolution'. The largely overlooked role of Recorde's publisher, Reyner Wolfe, in his life will also be evaluated.

Robert Recorde was a committed and devout Protestant. More might have been known about his beliefs had his two theological tracts survived.

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Acknowledgements

The wide range of Robert Record's abilities, interests and activities, meant that a correspondingly wide range of sources had to be consulted. I have had to depend extensively on the help of many librarians from many locations, off-line and on-line. Time and help have always been gladly given and are gratefully accepted. In Oxford I found succour in the Bodleian Library perhaps most appropriately in Duke Humfrey, at the History Faculty Library, the Radcliffe Science Library, the History of Science Library, the Taylorian Institute, the Sackler Library, the Law Library and at the Libraries of All Souls, Christchurch, Merton and Magdalen Colleges. The University Library of Cambridge and the Pepys Library there provided effective help at a distance, as also did the Library of the University of Columbia N.Y. As always, the resources of the British Library and the Public Records Office were invaluable. The availability of the service provided by Early English Books On-Line greatly eased problems associated with comparison of multiple editions of Robert Record's publications. I am grateful to Elizabeth and Gordon Roberts (TGR Renascent Books) for permission to reproduce an excerpt from one of their facsimile editions of Robert Recorde's books. The discovery by the late W. Gwyn Thomas of the manuscript relating to the trial of Recorde has proved critical. Finally I want to acknowledge the patience and good humour with which my family have accommodated to the collateral damage that research and preparation of this publication has inflicted on them over the past decade.

Contents

Part III Finale

Abbreviations

APC	Acts of the Privy Council.
BL	British Library.
CPR	Calendar of the Patent Rolls.
CPRI	Calendar of the Patent Rolls (Ireland).
CSP	Calendar of State Papers (Domestic); Calendar of State Papers (Foreign).
HMC	Historical Manuscripts Commission.
LP	Letters Patent.
PRO	Public Records Office.
STC	Short Title Catalogue (Revised).