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Samuel Pepys, Isaac Newton, James Hodgson, and the Beginnings of Secondary School Mathematics

A History of the Royal Mathematical School Within Christ's Hospital, London 1673–1868

Springer

History of Mathematics Education

"The Royal Mathematical School went through some vicissitudes in its early days and for a century or more Mathemats were the bully-boys of the Hospital and the terror of townees, but the R.M.S. inspired both Peter the Great (with the aid of two lads straight out of the Hospital) and Louis XIV to set up similar institutions in their own kingdoms, and before long Mathemats were proving their worth not only in the Royal Navy ... but also in the Maritime Service of the East India Company and captains of "Bombay Buccaneers." However, the greatest glory of the R.M.S. is in the history of exploration. A Mathemat surveyed the dividing line between Virginia and North Carolina, there were Mathemats—and the man who became the greatest Master of the R.M.S.—with Cook when he circumnavigated the world. Mathemats helped to open up the American West. Mathemats explored the interior of Australia." (p. 22)

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A History of the Royal Mathematical School
Within Christ's Hospital, London 1673-1868

Foreword by Benjamin Wardhaugh

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Foreword

Perhaps it's time for the history of mathematics to be re-titled "mathematics in the past." More and more scholars are turning to the history of mathematics not just for narratives about high-concept discovery and innovation—though we'll always need those—but also to seek to recover and understand the experiences with respect to both informal and formal versions of mathematics of a much wider variety of people, across all aspects of the societies and cultures in which they live.

On the one hand we have studies of mathematics as culture, and work on the visibility and the importance in general culture of the most creative mathematical developments and the most high-level technical achievements. On the other hand, greater attention is being paid to the rich and varied worlds of practitioners and amateurs, teachers and learners. In other words, there is an emerging history of numeracy, and of how members of society have identified, developed and drawn on numerical, geometrical, and logical relationships in their quest not only to survive with dignity but also to become more adept at improving their own lives and those of others around them. That is as it should be. Doing mathematics and "becoming mathematical" were and are part of culture just as much as are reading, writing and becoming literate. And, as parts of culture they are just as transformative, just as disruptive and potentially subversive, just as historically rich and interesting.

The launch of Springer's series on the history of mathematics education is particularly to be welcomed. As Ellerton and Clements rightly point out, mathematics educators have until recently paid little attention to questions of the "how did we get here?" kind. There is an urgent need for better understandings of how mathematics education can be and how it has been: of the variety and the levels of success of different ways of teaching and learning mathematics, as well as of the historical processes that have left us, ultimately, with "math anxiety" and "math wars."

Within any history of school mathematics, of mathematics education, or of numeracy in the United Kingdom, Christ's Hospital must have a special place. Since the creation of the Royal Mathematical School (RMS) as part of the school in 1673, it has been an unignorable part of the landscape of mathematics education. Its teachers—both the stars and the non-stars—and (some of) its alumni should be part of any story about mathematics and numeracy in the British Isles: and for that matter in Britain's overseas possessions. And the quality and the usefulness of the education that RMS provided, and the quality of the boys it sent out to employment at sea, were long a touchstone for the public visibility of mathematical learning and for debates about its utility.

Ellerton and Clements have already, through their remarkable work on the history of mathematics education, put permanently on the map the once-forgotten cyphering tradition and drawn attention to the quantity of archival material and the detail and depth of information that is available with respect to that tradition. This book is in some ways an extension of that work: but it is much more as well. By turning their attention to the Royal Mathematical School they have told an ambitious story which takes us right to the heart of both historical and modern debates about what it was and what it is to learn mathematics. It will be widely read and used, and I hope it will inspire more work of similar thoughtfulness and subtlety on mathematics in the past.

If it's at last beginning to be accepted that mathematics is part of culture, and the history of mathematics part of cultural history, books like this one fill an urgent gap in showing us what mathematics-as-culture actually consisted of. How mathematics was assimilated and passed on, what difference it made. What mathematics, where, and for whom? If the RMS redefined and extended the concept of school mathematics, Ellerton and Clements, through their study of that institution, have redefined and extended the concept of mathematical history.

Benjamin Wardhaugh   July 2016
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Overall Book Abstract, and Individual Abstracts
for the Ten Chapters of the Book

Overall Abstract

This book offers a history, for the period 1673–1868, of the Royal Mathematical School (RMS) at Christ's Hospital in London. The history has been consciously written from the perspective of the international history of school mathematics. Our analyses of the existing literature, of archival data, and our interpretations of those analyses, led us to conclude that RMS was the world's first major school to teach mathematics-beyond-arithmetic to teenage children as a continuous part of its overall program.

The following six research questions receive special attention:

1. Why was RMS established in 1673?
2. What factors need to be taken into account when evaluating Samuel Pepys's work with respect to RMS?
3. Were Isaac Newton's efforts to establish a suitable RMS curriculum successful?
4. To what extent is it true that most of the RMS masters during the first 125 years of RMS's existence were unsuccessful?
5. What was the role of cyphering in RMS's implemented curriculum?
6. Is it true that RMS became a prototype for "Mathematics for the People"?

Throughout the book we examine issues associated with those six questions through the lens of a lag-time theoretical perspective. Our analyses were not constrained by these questions, however, with other issues often being explored.

The best-known histories of Christ's Hospital are those written by William Trollope and Ernest H. Pearce, in 1834 and 1901, respectively. Although both Trollope and Pearce paid some attention to the work and influence of RMS within the school, they wrote from the perspective of the Grammar School (within Christ's Hospital), and did not comment on the importance of RMS so far as the international history of school mathematics is concerned.

RMS was established in 1673, largely through the work and influence of Christ's Hospital personnel, and the idea was supported by Samuel Pepys, who was Secretary of the Admiralty Commission at that time. During its first 35 years RMS struggled to offer an effective program in mathematics education—mainly because its curriculum was too difficult for teenage children but also because too little time was allowed in the school program for the teaching and learning of mathematics and navigation to RMS students. And, although "experts" such as Isaac Newton were consulted on curricular and staffing matters, the advice given by the experts was often less than satisfactory. Newton, for example, seriously overestimated the mathematical capacities of RMS students. As a result of the RMS curriculum being so difficult, and of insufficient time being allowed for the study of mathematics and navigation (and too much time for the study of Latin), the early RMS masters could not cope with the demands of their position. Not surprisingly, they were blamed for a state of affairs which was only partly of their own making.

In Chapter 6 it is argued that the situation changed in 1709, with the appointment of James Hodgson as RMS master. Hodgson, who held the position for 46 years, was a fine teacher and RMS thrived for much of his time as master. By the middle of the eighteenth

century Christ's Hospital had come to be regarded as having the best mathematics program of any school in Great Britain. The high reputation gained by RMS during its first century of existence was not mentioned by Trollope and Pearce—who both concentrated on the difficulties experienced by early RMS masters and glorified the work of William Wales, the RMS master between 1776 and 1798. Our analyses suggest that the extent and quality of Wales's contributions were greatly exaggerated by both Trollope and Pearce.

The groundbreaking developments in school mathematics at Christ's Hospital during the first 125 years of RMS's existence were not sustained, and Chapter 8 of this book reveals that during the period 1800–1868 school mathematics at Christ's Hospital gradually lost its reputation as an outstanding school so far as mathematics was concerned. By the time of the Taunton Royal Commission, in the 1860s, the Mathematics Department at Christ's Hospital was just one of many "high-level" British schools offering a strong academic preparation in mathematics for students who wished to proceed to university studies.

From a historiographical perspective, this book emphasizes how the history of a part of a school—the RMS, so far as this book is concerned—can be portrayed in very different ways, depending on the vantage point from which the history is written. In this book we have written the history of RMS within Christ's Hospital during the period 1673–1868 from the vantage point of international developments in school mathematics education—by contrast, Trollope and Pearce viewed the history of RMS from a Grammar School perspective. Our story is quite different from theirs.

Individual Chapter Abstracts

Chapter 1: Mathematics in the Christ's Hospital Curriculum Before 1673

Abstract: This chapter considers the place of mathematics in the curriculum at Christ's Hospital, a school in central London, during the period from the establishment of the school in 1552, to 1673, when the Royal Mathematical School began within the school. Although there is no known extant manuscript evidence it is almost certain that elementary arithmetic was the only mathematics taught at the school during those early years, and that students were introduced to that subject by Writing School masters who adopted classroom organizational approaches consistent with the cyphering tradition. There would have been an emphasis on numeration and the four operations, and on calculations involving money and weights and measures, with the intention of preparing students for apprenticeships as clerks. The chapter also draws attention to the influence of the Grammar School within Christ's Hospital. Grammar School masters taught Latin and Greek to children deemed to be "capable," and there was an expectation that some would win scholarships to the University of Cambridge or to the University of Oxford—where they would seek to become qualified lawyers or clergymen within the Church of England. When, in 1673, the Royal Mathematical School was created, Samuel Pepys and others assumed that mathematics and navigation studies would be at the pinnacle of academic pursuits within Christ's Hospital, but that assumption ran counter to a school ethos which had developed and matured between 1552 and 1673. The chapter concludes with a summary of six research questions for which answers will be sought in this book, as well as summaries of each of the ten chapters.

Chapter 2: Mathematics Beyond Arithmetic: Expanding the Domain of School Mathematics

Abstract: This chapter summarizes and analyzes educational, financial, military, and political contexts associated with a sequence of events which led to the creation, in 1673, of the Royal Mathematical School (RMS) within a school, Christ's Hospital, which had existed for more than 120 years. The creation of RMS, with its strong emphasis on mathematics and navigation education, represented a major shift in the school's curriculum and mission. The wisdom of the decision to establish RMS as a specialist mathematics/navigation education entity with a rigorous intended mathematics curriculum is questioned—given that there was no guarantee that suitability qualified teachers, with proven experience in teaching mathematics beyond arithmetic to 12- to 16-year-olds, would be available.

Chapter 3: Stars in the RMS Firmament 1673–1798

Abstract: This chapter identifies a firmament of 10 RMS stars—comprising Samuel Pepys, Jonas Moore, Christopher Wren, Robert Hooke, Isaac Newton, John Flamsteed, Edmond Halley, James Hodgson, John Robertson, and William Wales. It also identifies an eleventh person, Humfrey Ditton—a mathematics master at Christ's Hospital between 1706 and 1715—as someone who had an important influence on the future of RMS. The 10 stars illuminated the educational world within the Royal Mathematical School at Christ's Hospital at various times during the 125-year period 1673–1798. Not all the stars shone at the same time, with the first 30 years of RMS's existence being the time when more of the stars were shining together than at any other time. After briefly considering peculiar characteristics of each of the stars, and of Humfrey Ditton, their contributions to RMS's development are considered. It is concluded that the greatest, most positive, contribution came from James Hodgson, RMS master between 1709 and 1755.

Chapter 4: Years of Struggle for RMS 1673–1708

Abstract: The decision in the early 1670s to create a specialist mathematics/navigation training program within a school whose buildings had been badly damaged by the Great Fire of London was both creative and brave. It was creative because it recognized that Christ's Hospital could provide a steady source of boys for the kind of advanced training needed by apprentices in the Royal Navy or in the merchant marine. It was brave because such a scheme had never previously been tried anywhere in the world. This chapter tells of the teething troubles that Samuel Pepys, Jonas Moore, and others, experienced in developing the RMS curriculum and its associated teaching and learning program. It is argued that the program designed by Pepys and Moore was naïve in that the level of mathematics which it required of students was too high for 12- to 16-year-old boys who had virtually no formal education beyond elementary reading, writing, and cyphering.

Chapter 5: Developments in RMS Curricula 1673–1798

Abstract: Modern concepts of "intended curriculum," "implemented curriculum," and "received curriculum" are used in an analysis of RMS curriculum development during the

period 1673–1798. Although early RMS intended curricula were framed in terms of topics deemed to be appropriate for prospective navigators, RMS masters implemented a curriculum by which the boys prepared cyphering books which summarized what they were studying. From the outset the received curriculum—what the students experienced and learned from the implemented curricula—was assessed by external examiners who visited Christ's Hospital from time to time, and by experienced and reputable navigators associated with Trinity House, an independent, semi-government naval authority. Analysis reveals that both the RMS students and their masters struggled to cope with unrealistic curricular expectations, with the students being expected to learn too much, too quickly. When, during the period 1673–1709, the RMS program was seen to be failing, it was the masters who were blamed.

Chapter 6: RMS Comes of Age 1709–1755: The Hodgson Era

Abstract: Early in 1709 James Hodgson was appointed master of RMS, and he remained in that position until his death in 1755. The Hodgson era was a time when, against the odds, Christ's Hospital was able to provide a regular supply of graduates ready for gainful apprenticeship and service in the Royal Navy or the merchant marine. This success was especially evident in the early years of Hodgson's tenure as a result of his inspirational teaching and strong knowledge of both mathematics and navigation. Somehow, too, Hodgson, Fellow of the Royal Society, always managed to find time to be an able researcher, and he was a regular contributor to the Royal Society's journal. In the early 1720s he managed to write and have published a massive two-volume textbook, written especially for RMS students, which took account of all aspects of the RMS program. Between 1748 and 1755 an ageing Hodgson was assisted in RMS work by John Robertson, and, in 1755 Robertson succeeded Hodgson as RMS master. This chapter will draw attention to the serious lack of attention given to the Hodgson era by those who have written histories of Christ's Hospital. It is argued that this has led to a distortion of the history and significance of the influence of RMS in the eighteenth century.

Chapter 7: William Wales: RMS Master 1776–1798

Abstract: William Wales was RMS master from 1776 to 1798. At the time of his appointment he was obviously full of the practical navigation experience that might be expected of anyone accepting the responsibility of preparing boys to take up sea-related apprenticeships. Between August 1768 and September 1769, he had coped with the wilds, and the bitter cold, of Hudson Bay, in Canada, on a successful Royal Society mission to observe a transit of the planet Venus. Then, between 1772 and 1775, he had accompanied Captain James Cook on Cook's second major journey. During his time at Christ's Hospital, Wales developed a more positive attitude towards the work of the Grammar School than had previous RMS masters, and Trollope and Pearce claimed that he succeeded in stabilizing RMS operations. Both Trollope and Pearce lauded Wales as the greatest of the RMS masters, but in this chapter that assessment of Wales's performance as RMS master is problematized.

Chapter 8: Redefining School Mathematics at Christ's Hospital 1800–1868

Abstract: During the period 1800–1868 there was a large increase in the number of pupils at Christ's Hospital who studied mathematics beyond arithmetic. The school began to offer more mathematics to more students largely because senior Grammar School students needed to become better acquainted with mathematics if they were to have a chance of gaining honours degrees at the University of Cambridge. The RMS continued to exist, and its students continued to follow the traditional RMS curriculum, but with other elite schools increasingly embracing mathematics beyond arithmetic, it was not long before Christ's Hospital lost its reputation as having the best school mathematics program in the nation. This chapter explores factors which contributed to the widespread changes in school mathematics at Christ's Hospital during the period by analyzing answers that the Reverend William Webster—the long-serving head of the Mathematical School—gave, in 1865, to questions asked of him when he appeared before the Taunton Royal Commissioners.

Chapter 9: An Appropriate Theoretical Lens: Lag Time

Abstract: Lag time is defined as the amount of time between when a mathematical development (such as Newton's fluxions) was first made known and when that development came to be "normally studied" as part of the implemented mathematics curriculum in schools. In preparing this book we identified and analyzed pertinent archival and other data and then recognized that our interpretations of those data were consistent with lag-time theory. From the beginning of RMS, in 1673, logarithms and trigonometry were incorporated into the RMS curriculum, at a time when school children, elsewhere, were rarely expected to grapple with such topics. Edward Paget (in 1693) and Humfrey Ditton (in 1709) attempted to introduce sophisticated algebraic principles into the RMS curriculum, and in 1694 Isaac Newton attempted to persuade Christ's Hospital authorities to include the theory of mechanics. James Hodgson, in his 1723 textbook which was especially designed for the RMS program, made use of fluxions, which had only been made known, by Isaac Newton, in 1693. We conclude that anyone proposing to introduce topics based on recent mathematical developments into school mathematical curricula needs to take into account not only existing school cultures but also whether prospective learners will be cognitively ready to learn the new ideas.

Chapter 10: The Importance of the Royal Mathematical School in the History of School Mathematics

Abstract: This final chapter answers the following six research questions stated towards the end of the first chapter:

1. Why was RMS established in 1673?
2. What factors need to be taken into account when evaluating Samuel Pepys's work with respect to RMS?
3. Were Isaac Newton's efforts to establish a suitable RMS curriculum successful?
4. To what extent is it true that most of the RMS masters were unsuccessful during the first 125 years of RMS's existence?

5. What was the role of cyphering in RMS's implemented curriculum?
6. Is it true that RMS became a prototype for "Mathematics for the People"?

While carrying out the research for this book we came to recognize that authors of several general histories of Christ's Hospital tended to assess the effectiveness of RMS on the basis of whether they thought it assisted, or impeded, the work of the Grammar School within the school. A consequence of viewing the history of RMS from that vantage point was that William Wales was glorified as the most successful RMS master. In this book, however, the quality of Wales's work within RMS has been scrutinized, and it has been argued that James Hodgson, and not Wales, was the most successful of the RMS masters. Clifford Jones shares our view that, although Wales was an effective RMS master, the quality of his work at Christ's Hospital seems to have been exaggerated. We have viewed RMS from a history-of-school-mathematics perspective, and from that vantage point have concluded that it was the RMS adventure which showed the world that a school mathematics curriculum embracing logarithms, algebra, trigonometry, and practical, navigation-related, problem solving, could be offered, usefully, to teenage children. Hence, we have claimed that Christ's Hospital, largely through Samuel Pepys, Jonas Moore, Isaac Newton, and James Hodgson, redefined and extended the concept of "school mathematics." The chapter closes with a discussion of limitations of the research, and how a consideration of those limitations draws attention to various questions which need to be the subject of further research.

Preface to the Series

The first books in Springer's series on the history of mathematics education are being published in 2016. From the outset it was decided that the series would comprise scholarly works on a wide variety of themes, prepared by authors from around the world. We expect that authors contributing to the series will go beyond top-down approaches to history, so that emphasis will be placed on the learning, teaching, assessment and wider cultural and societal issues associated with schools (at all levels), with adults and, more generally, with the roles of mathematics within various societies. In the past, scholarly treatises on the history of mathematics education have featured strong Eurocentric/American emphases—mainly because most researchers in the field were scholars based in European or North or South American colleges or universities. It is hoped that the books in the new series will be prepared by writers from all parts of the world.

In addition to generating texts on the history of mathematics education written by authors in various nations, an important aim of the series will be to develop and report syntheses of historical research that have already been carried out in different parts of the world with respect to important themes in mathematics education—like, for example, "Historical Perspectives on how Language Factors Influence Mathematics Teaching and Learning," and "Historically Important Theories Which Have Influenced the Learning and Teaching of Mathematics."

The mission for the series can be summarized as:

- To make available to scholars and interested persons throughout the world the fruits of outstanding research into the history of mathematics education;
- To provide historical syntheses of comparative research on important themes in mathematics education; and
- To establish greater interest in the history of mathematics education.

We hope that the series will provide a multi-layered canvas portraying the rich details of mathematics education from the past, while at the same time presenting historical insights that can support the future. This is a canvas which can never be complete, for today's mathematics education becomes history for tomorrow. A single snapshot of mathematics education today is, by contrast with this canvas, flat and unidimensional—a mere pixel in a detailed image. We encourage readers both to explore and to contribute to the detailed image which is beginning to take shape on the canvas for this series.

Nerida F. Ellerton
M. A. (Ken) Clements

August, 2016

Preface to the Book

This book is about the creation and subsequent influence of the mathematics department within Christ's Hospital, a school which was established in central London in 1552, 465 years ago (Manzione, 1995). The school still exists, but is now located at Horsham, about 47 miles south of its original location. We decided to study intensively the early history of school mathematics at Christ's Hospital because our research suggested that it was in that school that the modern idea of "secondary school mathematics for all" had its beginnings.

Although we believe that the findings of the research described and summarized in this book have confirmed the view that modern secondary school mathematics "for all" began at Christ's Hospital, we recognize that that claim is likely to be contested. We shall be pleased to read serious counter-commentaries which not only take full account of the analyses of data and interpretations presented in this book, but also report and analyze, carefully and fully, data which have *not* been taken into account in the analyses we present in this book.

This book appears as part of Springer's "history of mathematics education" series—for which we (Ellerton and Clements) have overall editorial responsibility. Our aim for the series is to generate a scholarly body of literature on the history of mathematics education, especially the history of school mathematics. Mathematicians have always been interested in the history of mathematics but, until recently, mathematics educators have paid little attention to the history of school mathematics. Yet, today vast amounts of money and time are being spent on servicing school mathematics in all parts of the world, and there is much debate—often bitter debate—about issues associated with school mathematics curricula, mathematics teaching methods, assessment and reporting of mathematical learning, mathematics teacher education (both pre-service and professional development), etc. There is also much discussion on the roles that governments should play in framing school mathematics, and on the possibility, and desirability, of internationalizing curricula and assessment. There is an obvious and urgent need to develop well-researched historical perspectives on these and many other related key issues.

School mathematics is very different now from what it was 200 years ago. In the early 1800s most children in most countries rarely attended formal schools. Of those who did, most did not study any mathematics beyond elementary arithmetic. Very few school teachers stood at the front of a room and taught whole classes, and many students, even those studying mathematics, did not own a mathematics textbook. Written examinations of any kind were not used. Most teachers of mathematics did not have formal qualifications in mathematics (Clements, Keitel, Bishop, Kilpatrick, & Leung, 2013; Ellerton & Clements, 2014). At the beginning of the nineteenth century less than 1 percent of all the world's children learned how to add, subtract, multiply or divide common fractions or decimal fractions while they were at school. An even smaller proportion studied logarithms, or geometry, or algebra, or trigonometry (Clements & Ellerton, 2015). We believe that before one can constructively examine and interpret modern twenty-first-century developments one needs to know more about the situations which prevailed before those developments occurred.

The relatively few scholars who have given serious attention to the history of school mathematics have tended to do so from top-down, largely Eurocentric, and high-

mathematical vantage points. The emphasis has been on how curricula and textbooks in post-elementary school mathematics were passed downwards from universities and colleges—and especially from leading institutions located in Europe and in North America. The role of textbooks in the history of secondary school mathematics has been much emphasized, and efforts by well-known European mathematicians who sought to improve school mathematics have tended to be identified.

Results of TIMSS, PISA, and other international comparative studies in the second half of the twentieth century suggested that the world might have something to learn about the history of school mathematics curricula and assessment, and about the history of the teaching and learning of mathematics, from data generated by books and manuscripts emanating from countries in Asia, Africa, Oceania, and the Middle East. In this new Springer series a conscious effort will be made to take advantage of the research of knowledgeable scholars in nations such as Australia, China, Ethiopia, Finland, India, Iran, Japan, Korea, New Zealand, Pakistan, Papua New Guinea, Singapore and South Africa—although, of course, well-credentialed researchers from Europe and America will not be overlooked.

How does the present book fit into a series which aims to do what we have just outlined? Well, it was at Christ's Hospital, in 1673, that the study of mathematics beyond elementary arithmetic was first offered to children other than the privileged few. And, because, for the next 200 years, graduates of the Royal Mathematical School at Christ's Hospital would be scattered across the world, especially into British colonies, the influence of the Christ's Hospital mathematics program on the growth of the concept and influence of school mathematics in many nations around the world was profound.

We wish to thank librarians, archivists and the staff at the British Library, Guildhall Library, London Metropolitan Archives, the Royal Observatory and the National Maritime Museum at Greenwich, the Bodleian Libraries at the University of Oxford, the Cambridge University Library, the Pepys Library at Magdalene College within the University of Cambridge, the Phillips Library at the Peabody Essex Museum, Salem, Massachusetts, the Butler Library at Columbia University, New York, the Clements Library at the University of Michigan, the Houghton Library at Harvard University, the Library of Congress (in Washington DC), the Wilson Library at the University of North Carolina at Chapel Hill, the Beinecke Library at Yale University, the Winterthur Museum in Delaware, the Special Collections Research Center in the Swem Library at the College of William and Mary and the Rockefeller Library (both in Williamsburg, Virginia), the New York Public Library, the State Library of Victoria (Australia), and the Milner Library at Illinois State University, for locating relevant manuscripts, artefacts, and books for us. We also visited Christ's Hospital—now located at Horsham, 47 miles south of central London—where we examined artefacts relating to matters about which we have written in this book.

We feel deeply honored that Dr Benjamin Wardhaugh, of All Souls College, within the University of Oxford, agreed to write the foreword to this book. Benjamin has written much on the history of mathematics and of mathematics education, and in December 2014 and December 2015 we were privileged to speak at high-level conferences organized by Benjamin and held at All Souls College. Our encounters with Benjamin and with the other scholars who attended those conferences certainly helped us to define, refine, and extend our knowledge and understandings of the history of school mathematics in the United Kingdom. In addition, we would like to thank Dr George Seelinger, the Head of the Mathematics

Department at Illinois State University (in which we both work), for encouraging us in our research endeavours.

We also wish to thank Clifford Jones and Ken Mansell, volunteers in the Christ's Hospital Museum, who took time to answer questions that we asked of them. Clifford's 350-page book on the history of the Royal Mathematical School (RMS) at Christ's Hospital appeared in December 2015 (Jones, 2015). When we started writing this present book we were not aware that Clifford Jones was writing a history of RMS. We purchased Clifford's book as soon as we became aware it had been published, and have profited from reading it.

There are differences between the emphases in Clifford's book and ours: Clifford's tells the story of RMS from a school perspective, and this present work is written from the perspective of the international history of school mathematics. We do not accept Clifford's contention that Samuel Pepys did not have much to do with the creation of RMS. Another important difference is that, unlike Clifford, we have emphasized that from RMS's beginnings, the "cyphering tradition" had a strong influence on how RMS students were expected to learn. Despite such differences we are confident that readers will find the two accounts highly complementary.

After finishing our writing for this book we began to reflect on who might be especially interested in what we have written. Obviously, Clifford Jones will be, as will many old-Blues within the Christ's Hospital community. We want to assure Clifford and the old-Blues who read this book that we have developed a genuine admiration for what the school stands for now, and what it has stood for over the centuries.

The world of publishing has changed considerably over the past few decades, and that has had an impact on how we have written this book. In the past, authors could assume that a whole book, or at least quite a few chapters in it, would be read by interested persons. But now, e-books and individual chapters of a book in digital form are readily available, and from the outset we recognized that that should affect how we would go about writing individual chapters. Thus, for example, a careful reader of this book might notice that sometimes points made in earlier chapters are repeated later in the book. Obviously, because readers may want access to just one of the chapters in the book, it made sense for us to repeat material covered in earlier chapters. We have attempted to limit such repetition to cases where what is being repeated represents essential knowledge if the present chapter is to be understood as a stand-alone document. Another sign of the times is that there is a reference list at the end of *each* chapter, *and* a *composite* reference list after all 10 chapters have been presented. The reason for that is simple: readers who have access to just one chapter are likely to want to have access to a fully documented statement setting out the works to which reference is made in the chapter.

We hope that many historians of education, especially those interested in the history of school mathematics, find this book to be worthy of their attention. There are strong political and educational differences and undercurrents within that community of scholars, and undoubtedly some Continental researchers will disagree with our claim that the beginnings of modern secondary-school mathematics were to be found at Christ's Hospital. Although we also expect reactions to our emphasis on the importance of the cyphering tradition within the Royal Mathematical School, we would wish to add that until recently very little had been written about that tradition.

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Chapter 1

Mathematics in the Christ's Hospital Curriculum Before 1673

Abstract: This chapter considers the place of mathematics in the curriculum at Christ's Hospital, a school in central London, during the period from the establishment of the school in 1552, to 1673, when the Royal Mathematical School began within the school. Although there is no known extant manuscript evidence it is almost certain that elementary arithmetic was the only mathematics taught at the school during those early years, and that students were introduced to that subject by Writing School masters who adopted classroom organizational approaches consistent with the cyphering tradition. There would have been an emphasis on numeration and the four operations, and on calculations involving money and weights and measures, with the intention of preparing students for apprenticeships as clerks. The chapter also draws attention to the influence of the Grammar School within Christ's Hospital. Grammar School masters taught Latin and Greek to children deemed to be "capable," and there was an expectation that some would win scholarships to the University of Cambridge or to the University of Oxford—where they would seek to become qualified lawyers or clergymen within the Church of England. When, in 1673, the Royal Mathematical School was created, Samuel Pepys and others assumed that mathematics and navigation studies would be at the pinnacle of academic pursuits within Christ's Hospital, but that assumption ran counter to a school ethos which had developed and matured between 1552 and 1673. The chapter concludes with a summary of six research questions for which answers will be sought in this book, as well as summaries of each of the ten chapters.

In the Beginning: Christ's Hospital 1552–1673

In 1552, the City of London established a new school, called Christ's Hospital, in what had previously been the Grey Friars Roman Catholic monastery, in Newgate Street, central London (Manzione, 1995). King Henry VIII had shut down the monastery in 1538, as part of his "dissolution of the monasteries" mandate.

Although the purpose of the new school was made clear from the outset—it was to be mainly for children of London's poor—there were obvious questions which needed to be answered about how that purpose should be achieved. How would the school be financed? Who would administer the school, and who would be the teachers? What would the students be expected to learn? And, given that the school was to be a large boarding school, how would the program of studies be linked with the need to feed, clothe, and care for the children? It was unlikely that any funding would come directly from the Crown because in 1546, when Henry VIII handed the buildings to the City of London, it had been made clear that the Crown would not meet costs associated with any new enterprise at the venue.

It would be inappropriate here to provide a detailed analysis of how those questions were answered during the early years of the school's history, for that has already been done by various scholars who have written histories of the school (e.g., Allan, 1937; Committee of Old Blues, 1953; Jones, 2015; Manzione, 1995; Pearce, 1901; Trollope, 1834; Wilson, 1820). This book has a narrower focus—specifically, an analysis will be provided of mathematics education at Christ's Hospital between 1673 and 1868, especially within the Royal Mathematical School (hereafter "RMS") which was founded in 1673. It will be argued that, from both national and international perspectives, the creation of RMS represented a watershed in the history of school mathematics.

The purpose of this chapter is to identify political and educational dimensions of a developing school culture which affected what the school was able to do when it established RMS. The 1673 move to establish RMS was not one that would have been expected, given the kind of schooling and care provided at Christ's Hospital during the period 1552–1673.

Around 1550 the population of England was about 3 million and that of the city of London about 70,000 (Wrigley & Schofield, 1981). Both populations were growing rapidly—indeed, during the period 1450–1550 London's population had increased fourfold, and by 1600 it would reach 200,000 (Finlay, 1981). In 1552 the City of London, responding to pressures generated by the existence of large numbers of young children begging in the streets, and by high levels of lawlessness (Beier, 1974), agreed to King Edward VI's request for the City to assume responsibility for three former Roman Catholic monasteries which had been closed by Henry VIII (see Figure 1.1). The buildings would now be termed "Hospitals" and be called St Thomas the Apostle, Bridewell, and Christ's Hospital.
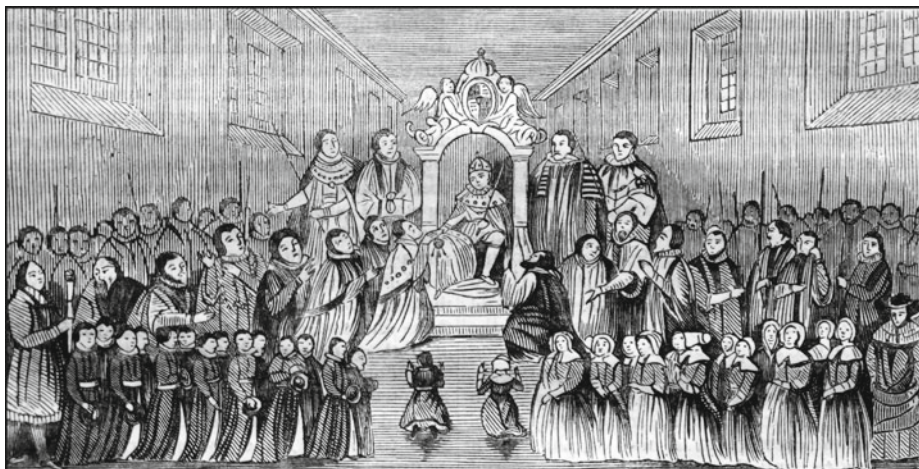
Figure 1.1. Edward VI, presenting the charter of the Hospital to the Corporation of London. in June 1553. [This illustration is from an old painting by Hans Holbein, reproduced in Historical and Descriptive Notice of Christ's Hospital, November 21, 1840, p. 1].

The newly-created institutions would have different functions: St. Thomas the Apostle would concern itself with the care of the sick and needy; Christ's Hospital would attend to the physical and educational needs of orphans and other destitute children and adults; and Bridewell would become a correctional workshop to occupy usefully the time of those who, although physically capable, had become idle and attracted to crime (Clark & Slack, 1972;

Griffin, 1998; Historical and Descriptive Notice of Christ's Hospital, 1840; Manzione 1995; Slack, 1988).

With a large number of children to feed, clothe and educate, buildings to maintain, equipment to purchase and maintain, and administrators, nurses, and teachers to pay, Christ's Hospital needed regular and reliable sources of income. It was decided that the money would come largely through bequests and donations, with administrative guidance being provided by well-to-do governors. According to Manzione (1995):

> The hospitals provided a two-pronged opportunity for their governors to do good deeds by helping the poor, and to provide status positions for the London elite. The presidency of the hospitals and the governorships allowed men with vast experience to exercise their talents beyond the confines of their trades and daily lives, to serve their fellow Londoners in a useful, productive, and visible capacity. Although the governors of Christ's and the other hospitals were drawn from a small elite, their charges came from a variety of backgrounds and circumstances. These same men who served as governors of the royal hospitals not only gave money to the cause but gave their time, energy and, above all, a guiding sense of purpose. (p. 137)

From the beginning, wealthy benefactors tended to make donations and bequests to enable the most capable of the Christ's Hospital graduates to take up "exhibitions" (i.e., scholarships) at the University of Cambridge or the University of Oxford. This had profound curriculum implications—because boys proceeding to a university needed to be able to read scholarly texts written in Latin or Greek. Therefore, so the argument went, a Grammar School was needed at Christ's Hospital, in order to provide the necessary preliminary studies in the classics for those who, upon leaving school, would proceed to higher-level studies.

Surprisingly few details are known about the education programs at Christ's Hospital during the first 25 years of its existence as a school. That said, there can be no doubt that the early programs were heavily influenced by instructions given by those who left large legacies to the school. Donations and bequests were the life-blood of the school, and the wishes of donors had to be respected.

The Emergence of Christ's Hospital as a School for the Poor, but with Elite Tendencies

From its beginning, Christ's Hospital had separate Grammar and Infant schools (Manzione, 1995; Trollope, 1834). In 1562 the Grammar School master was one of the highest-paid employees in the school—he received 15 pounds a year, and was assisted by an "usher" who was paid 10 pounds a year. The Grammar School masters were allocated residences within the school, free of rental charges (Trollope, 1834). By contrast, John Watson, a clerk, received 10 pounds a year, and an extra 3 pounds 6 shillings and 8 pence per year for being the Writing School master (Committee of Old Blues, 1953, p. 7). Thus, the work of the Grammar School master was judged to be much more valuable than that of Writing School master, despite the fact that the Grammar School master not only dealt with fewer students but also had a well-paid usher to support him.

According to Trollope (1834), from the outset the boys in the Grammar School not only "made considerable progress in classical knowledge" (p. 68) but they also acquired religious knowledge. Such was the status of the Grammar School that the "undermaster" (or usher) had no trouble attracting "outside" private students who were taught classics on the school premises. This was permitted and justified by the argument that the nation needed to train a

new set of clergymen committed to the recently-created Church of England—and, from its beginning, Christ's Hospital was thought to be an important part of the mechanism by which that might be achieved. It was regarded as axiomatic that future clergymen needed to study Latin and Greek, and therefore the Grammar School at Christ's Hospital, whose main duty was to teach Latin, Greek, and perhaps Hebrew, was of national importance.

During the period 1552–1673 there was a steady increase in "tagged" scholarships, funded by wealthy individuals, which enabled Christ's Hospital graduates to proceed to university studies and, ultimately, to complete degrees. The university most-named in the bequests was the University of Cambridge. Fortunately, for the historian, scholarships that Christ's Hospital students could take in order to proceed to that University were listed by Robert Potts (1855), in his *Liber Cantabrigiensis*: *An Account of the Aids Afforded to Poor Students.* Brief details of scholarships available, between 1552 and 1673, to Christ's Hospital students proceeding to the University of Cambridge are shown in Table 1.1 (which also lists a few scholarships for students wishing to attend the University of Oxford). After 1673, scholarships to students from Christ's Hospital for courses at either the University of Cambridge or the University of Oxford continued to be made available through bequests.

Carol Manzione (1995) maintained that between 1552 and 1598 "only a tiny minority of the alumni of Christ's Hospital" attended the University of Cambridge or the University of Oxford (p. 151). To bolster her argument, she cited James Frith's (1803) edited collection and also data from an analysis carried out by George A. T. Allan (1937) which showed that, of the students who attended Christ's Hospital between 1552 and 1598, only 29 subsequently enrolled at either Cambridge or Oxford. That number may seem to have been small for a 46-year period, but the very existence of the scholarships gave the Grammar School a status which would not otherwise have been easy to establish.

According to Trollope (1834), by the year 1661 more than 260 pounds was being paid annually to support seven former Christ's Hospital students at the University of Cambridge, and almost 60 pounds annually to support a student at the University of Oxford. To gain a scholarship a student needed to have studied the classics while at school, and therefore the Grammar School had come to be regarded, and to regard itself, as crucially important in the development and maintenance of a strong academic reputation within and beyond the school.

Between 1552 and 1673, then, part of the emerging school culture embraced the idea that academically talented boys at Christ's Hospital should have a chance of proceeding to university studies (Trollope, 1834). Since facility with classics was a prerequisite for entry to both the University of Cambridge and the University of Oxford, the Grammar School focused on the study of Latin and Greek texts. That inevitably resulted in the highest achievers receiving the loudest plaudits. Given the circumstances, it was not surprising that elitist tendencies developed within the school.

What needs to be emphasized here is that almost all of the Grammar School students at Christ's Hospital who were prepared for possible entry to the University of Cambridge or the University of Oxford—these prized students were called the "Grecians"—would have studied virtually no mathematics beyond arithmetic during their years at school. Most would have spent a short time in the Writing School, where they would have been introduced to an elementary arithmetic curriculum which included the Hindu-Arabic numeral system, and calculations with the four operations on money, weights and measures. But many—and probably most—of the Grammar School boys who proceeded to a university would have left school not knowing their multiplication tables.

Table 1.1

Scholarships Available to Christ's Hospital Students to Attend the University of Cambridge or the University of Oxford, 1552–1673 (from Potts, 1855)

Source of Funding, and Year	Amount (if Given) and Purpose of Funding	For Which University?	Potts (1855)
Thomas Dixon, 1585	6 pounds each year	Either Cambridge or Oxford	p. 457
Lady Mary Ramsey, 1596	20 pounds a year, towards the maintenance of 12 poor scholars	6 at Cambridge, 6 at Oxford	p. 209
Lady Mary Ramsey, 1601	4 scholarships to St. Peter's College, for those who intended to take holy orders	Cambridge	p. 209
Lady C. Barnardiston, 1633	3 scholarships to St. Catherine's Hall (preference to Christ's Hospital students for two of them)	Cambridge	p. 218
Mr W. Richards, 1649	2 exhibitions to Emmanuel College (preference to Christ's Hospital students)	Cambridge	p. 365
Mr William Rudge, 1652	150 pounds, for sending poor scholars "bred up at Christ's Hospital"	Cambridge	p. 458
Mr John Perryn, 1656	5 pounds per year towards the maintenance of one scholar from Christ's Hospital	Cambridge	p. 458
The Rev. Abraham Colfe, 1656	1 scholar from Christ's Hospital	Cambridge	p. 433
Mr Thomas Stretchley, 1661	7 pounds per annum, for each of 2 scholars from Christ's Hospital,	Cambridge	p. 458
Mr John Brown, 1662	6 scholars from Christ's Hospital, 3 at Emmanuel College and 3 at Christ's College	Cambridge	p. 298 and p. 366
Mr William Williams, 1665	8 pounds per year for 7 years for a scholar from Christ's Hospital	Cambridge or Oxford	p. 458
Mr Erasmus Smith, 1666	100 pounds per year for poor children belonging to Christ's Hospital	Cambridge or Oxford	p. 458
Mr Thomas Barnes 1667	8 poor children of Christ's Hospital	Cambridge	p. 458
Mr Thomas Rich, 1672	6 pounds each, 2 exhibitions, for 2 children of Christ's Hospital	Cambridge	pp. 458–459
Sir John Smith, 1673	6 pounds 13 shillings and 4 pence, for a poor scholar who had been brought up in Christ's Hospital	Cambridge or Oxford	p. 459

The Writing School at Christ's Hospital

From the outset the school created a so-called Infant School, for the youngest children, and a Grammar School in which those children who were deemed to be academically capable studied classical and religious texts. Although criteria by which Grammar School children would be selected have not been specified in school records, obviously there was a great divide between criteria for selection to the Infant School and those for the Grammar School.

In 1577, Dame Mary Ramsey provided substantial funds for the development of a Writing School at Christ's Hospital (Freeman, 1913). The purpose of the Writing School was to assist students who had learned to read to take the next step by learning to write. The Writing School's curriculum always included "cyphering," that is to say the writing of arithmetical rules and cases, and the solving of arithmetical exercises, in a special book known as a "cyphering book" (Christ's Hospital, 1595; Ellerton & Clements, 2012). The idea was that students who learned to write and to calculate would be ready to take up apprentice-ships as clerks or shopkeepers when they left school. Although only a tiny proportion of 15-year-olds in and around London could read, write, and calculate, Christ's Hospital aimed at getting most of its pupils to that stage (Manzione, 1995; Page, 1954; Shelley, 1710).

More will be said about the cyphering tradition in later chapters, especially in Chapter 5. Here it suffices to note that during the period 1552–1673 most Christ's Hospital students spent some time in the Writing School, and since there was always only one writing master (City of London, 1840), sometimes assisted by one or two ushers, it was impossible for a teacher to devote much time to helping individual learners. Because there were always large numbers of children in the Writing School who had different levels of understanding of arithmetic, whole-class teaching from the front of a room was not feasible—and, in any case, there was a centuries-old recitation tradition whereby arithmetic was taught by getting pupils to prepare handwritten cyphering books. Part of the process was for each student to participate in one-on-one, question-and-answer recitation sessions with his or her teacher (Ellerton & Clements, 2014). On leaving school, the pupils would take their cyphering books with them, for guidance. Although, as far as we know, there are no extant cyphering books prepared by Christ's Hospital pupils during the period 1552–1673, those books undoubtedly existed. Each would have featured statements of rules and cases for numeration, addition, subtraction, multiplication, division, money calculations, weights and measures calculations, reduction and, for some, the celebrated "rule of three." Entries on each page would have been completed in the pupil's neatest handwriting (Ellerton & Clements, 2012, 2014).

In 1664 Samuel Pepys consulted Edward Cocker (1631–1675), a well-known, London-based writing master and author of mathematics texts. Pepys recorded in his diary that he was extremely impressed with Cocker's work. It was no surprise that Cocker was simultaneously a writing master and a teacher of arithmetic, for that combination was traditional. Almost all writing masters specialized in the teaching of arithmetic. In the sixteenth and seventeenth centuries, elite "public" schools like Eton, Harrow, Westminster, and St Paul's did not include mathematics beyond elementary arithmetic, and perhaps elementary geometry, in their curricula. With their eyes firmly on requirements of the University of Cambridge and the University of Oxford, they prepared their best students in Latin, Greek and Hebrew (Leach, 1911). The Grammar School at Christ's Hospital did the same with its Grecians—despite the different backgrounds of the boys at the elite schools and those at Christ's Hospital. Christ's Hospital had quickly become a school for the poor, but one with high aspirations.