A CAMBRIDGE CORRESPONDENCE CLASS IN ARITHMETIC FOR WOMEN

James J. TATTERSALL
Providence College, Providence RI 02918, USA
tat@providence.edu

ABSTRACT

In late nineteenth century England the Association for Promoting the Higher Education of Women in Cambridge began sponsoring a series of correspondence classes for women vying for certificates on the Cambridge Higher Local Examinations. These courses were designed for women who lived in remote areas devoid of suitable teachers and for governesses who did not have sufficient control over their time to permit them to attend classes or to receive oral instruction. The instructor of the arithmetic class sent candidates a set of mathematical problems at fortnight intervals. After forwarding their answers, students read related material and prepared for the next problem set. The teacher read over their work and returned it with comments. The teacher's correspondence illustrating his educational philosophy and tips on how to prepare for the examination is highlighted.

In November 1867, at a time when women could not earn a degree at any university in Great Britain[1], Anne Clough and Josephine Butler, both prominent in the Victorian women's suffragist movement and each with a keen interest in woman's education, founded the North of England Council for Promoting the Higher Education for Women. The organization, originally representing associations of school mistresses from several large northern English towns, established a program of lectures and courses for women. In an attempt to improve the intellectual standards prevalent in girls' schools, they petitioned Oxford and Cambridge Universities to offer an examination for women of sufficiently high standard that would serve as a test for those who wished to enter the teaching profession. Accordingly, Cambridge University initiated the Higher Local Examinations for Women in 1869 aimed at those over eighteen who wanted to be teachers, which upon completion would provide them admission to higher education.[2]

Henry Sidgwick, fellow of Trinity College Cambridge, and activist Millicent Garrett Fawcett formed a committee, which segued into the Association for the Promotion of the Higher Education of Women in Cambridge. In 1870, Henry's future wife Eleanor[3]was instrumental in establishing a series of "Lecture for Ladies" that covered a number of relevant academic topics including practical arithmetic, algebra, and geometry.[4]Cambridge at the time was a small market town with limited housing. Nevertheless, Sedgwick managed to secure lodgings, under the supervision of Anne Clough, for five women

[1] In 1878, the University of London became the first academic institution in the United Kingdom to offer post-secondary degrees to women.
[2] In 1858, the Cambridge University had initiated Local Examinations with the aim of raising the standards of education.
[3] Nora, as she was known to her friends, studied at Newnham Hall, precursor to Newnham College. Albeit coached by M.N. Ferrers of Christ College for the Mathematical Tripos, she declined to sit for the examination. She served as a physics researcher for her brother-in-law Lord Rayleigh. Her brother Arthur served as Prime Minister from 1902 to 1905.In 1902 she succeeded Anne Clough as Principle of Newnham College.
[4] Other topics include: mechanics, astronomy, geology, chemistry, physical geography, English and modern history, English literature, logic, political economy, moral and mental philosophy, Latin, Greek, French, German, and harmony.

interested in attending the lectures. Demand for the lectures escalated. As a result, larger accommodations and a lecture hall were procured by Sidgwick near St. John's College. In addition, a lending library was made available to women who attended the lectures.

In the fall of 1872, to alleviate the pressure to find adequate housing and for the women who were not able to reside in Cambridge to attend the lectures, the committee initiated a series of correspondence classes under the supervision of Mrs. Annette Peile that was supported by faculty from several Cambridge colleges. Walter William Skeat offered a class in English literature, Greek by John Peile, geometry and algebra by James Stuart, logic by John Venn, and political economy by Henry Sidgwick.[5] A fee of £2 was implemented,[6]sufficient to make the courses self-sufficient, high enough to keep off people who are not seriously about work, and sufficient to ensure that those who join the classes will be anxious to get an adequate return for their money.

General instructions for those interested in enrolling in a correspondence course stressed that the program was not much more than an assistance in self-education, and therefore should in no sense be taken when efficient oral teaching could be obtained. Students should be prepared to carry out honestly and perseveringly the directions of their teachers and must be capable of taking hints, for detailed explanation would be impossible. As a consequence, they should have an acquaintance that they can consult who understands the rudiments of the subject. While an examination is perhaps not to best way to identify a good teacher, correspondence courses were felt to be a novel approach to pedagogical training. Whereas in classrooms students merely listen and seldom ask questions, in correspondence courses students must answer and ask questions. In order to encourage such communication students were provided with prepaid half penny post cards (Hudson 1872a).

Thirty students enrolled in the first correspondence course in arithmetic offered by William Henry Hoar Hudson, a mathematical lecturer at St. John's and St. Catherine's Colleges, Cambridge, covering topics such as measurement, vulgar fractions, ratio, proportion, decimal fractions, and interest. In order to access their potential and avoid unintended consequences, he asked them, in an introductory letter, to send him answers to the following questions (Hudson 1872b):

- For what object are you studying arithmetic?
- Have you access to a library?
- What time do you have available for study?
- To what extent is your time occupied in teaching or otherwise?
- Can you devote 2 ½ hours at one sitting, once a fortnight, to answer a set of questions?
- Can you devote one hour a day to reading arithmetic?
- From what book or books have you learnt arithmetic?
- What books on arithmetic can you consult?

[5] Skeat was a philologist and later cofounder of Newnham College. Peile, also a philologist and Annette's husband, became master of Christ's College, Cambridge. Stuart was professor of mechanism and mechanics at Cambridge before becoming Lord Rector of St. Andrews University. The logician Venn, from Gonville and Caius College, Cambridge, compiled the *Alumni Cantabrigienses*, a biographical record of members of the university from earliest times to 1900. Nevertheless, he is best known for his set theoretic diagrams. Sidgwick was a philosopher and economist. The Sidgwick Site, now home to a number of arts and humanities faculties at the university, is named for him.

[6] Equivalent in purchasing power in 2017 of about $200 (Measuring worth, n.d.). Governesses were eligible for a discount.

• Enumerate parts of arithmetic you have learnt
• Have you any knowledge of algebra?

Students were advised that they must be accustomed to and be prepared for serious work, for a problem set will be sent every fortnight, usually on alternate Thursdays. A stated time, not to be exceeded, will be given at one sitting to each set, with no help from books, tables, or any source whatsoever. When done, they should send their answers with questions on any difficulties and a report of their progress stated in a clear, concise, and definite manner. Sometime during the next week, he will look over the papers and return them with comments. In the meanwhile, they should be reading and preparing for the next paper.

In his first circular letter (Hudson 1872-73), he reminded participants to be punctual in sending in their papers and letters and, at this stage, not to attach too much importance in merely answering the problems posed for their progress will depend much more on their reading, thought, and practice. They should read in the 'Cambridge sense', which entails lots of writing, per using sources critically with an aim of looking for mistakes, and read with pencil in hand. He cautioned them to aim first at understanding each problem. Never try to reproduce the words of a book in answering questions, but to give their own explanations in their own language.

He admitted that the class will, in all probability, contain members of varied degrees of knowledge and ability. Hence, his problems will usually be general ones. Nevertheless, they may contain questions that are beyond their reading. As their reading advances, more and more of the questions will come within their reach. He hoped that their reading will advance regularly and steadily, but not necessarily rapidly. Thorough understanding takes reading, practice, and thought. Through practice the basic arithmetic operations of addition and multiplication will become 'almost instinctive' for failure to implement them will be an impediment to further progress. He advised them to write clearly, never try to conceal ignorance by obscurity, and not to use rules or symbols that they do not understand. At any time, however, he would be willing to give a brief answer to a question that he can answer on a post card.

In his second letter, he discussed possible textbooks they might consult.[7]He warned students that many arithmetic books may contain valuable methods and useful examples, but lay too much stress on 'rules', neglecting to explain principles and on this account they are bad for educational purposes. They should become imbued with the principles, and familiar with the facts of arithmetic, for then they will be free from slavery to rules. On no account are they to learn or practice a 'rule,' the reason of which they do not thoroughly comprehend. He urged students to,

> Take nothing on trust. It will be far better to solve a question by a method of your own, which you do understand, even if it be a long way of arriving at the answer,

[7] Although there was no one book on arithmetic that he could give a qualified approval, Augustus De Morgan's *Elements of Arithmetic* (5th ed., London, Walton, 1969) was very good but contained too few examples. James Harris's *Graduated Exercises in Arithmetic and Mensuration with Key* (London, Longmans, 1872) has a good collection of examples but no bookwork. *The Science and Art of Arithmetic* (London, Whittaker, 1970) by Adolf Sonnenschein and Henry Arthur Nesbitt was somewhat awkwardly arranged, but contained some excellent hints for teaching. Since several of the class are actually engaged, or are about to be engaged in teaching, he felt that it will be the most convenient book on the whole.

than to allow yourself to be led blindfold by a 'rule,' by a short cut, over steps which you cannot see.

He offered them one more piece of general advice:

> Acquire the habit of concentration. In reading, especially a new part of the subject, never allow your thoughts to wander. Try and arrange to be free from interruptions, and in a silent room. If you are new to intellectual works, and find such close attention difficult, do not, at first attempt to read for too long.

In his third letter, he urged students in explaining their answers:

> To imagine that you are addressing an intelligent child, ignorant say of arithmetic, except that which comes earlier in the point in question … Never use words that you do not understand … such a child would be sure to ask you the meaning of them. Never use symbols that you do not understand …Learn the exact meaning of symbols and never use them in any other sense … Never use arithmetical terms in any other than their technical sense.

He stressed that they read each question carefully and understand it. Do not ask themselves 'what rule should I use?' Use only the rule of common sense. Attend to the logic of their work and let their solution 'tell its story.' Let the argument be clearly indicated and take care to copy down figures correctly.

In his fourth letter, he stressed the primary importance of doing their own work. He noted that it appears that some of them have not understood his directions and letters. If that be the case, they should ask him at once for explanations. He lamented that he is not getting enough questions from them, nor of the right kind. He wanted questions concerning some actual difficulty that they have felt in thinking over what they have read, and these questions must be stated so definitely that he can see how much is clear to them, and when the difficulty began. He noted that several of his students have discontinued the practice of leaving a margin by the side of their answers, and consequently he cannot criticize their solutions.

In the fifth letter, he expressed concern that some students still work by rules and not by common sense. He warned them that the mechanical rule of three does not apply to all problems. The bulk of the rest of the letter contains study hints for those taking examinations as would a Cambridge coach preparing men for a tripos examination. In particular,

- Don't omit the names of concrete quantities.
- Never use an approximation without stating that it is so.
- Don't use incomplete sentences.
- Make a clear distinction between scratching out and cancelling.
- Show clearly what you mean for the answer.
- Use words and symbols accurately.
- Nothing but practice will give you the tact to discern when it is most convenient to use vulgar and when decimal fractions.

His sixth letter (Hudson 1873), was addressed only to candidates for the Higher Local Examination in June. He stressed that any examination is a physical strain and they should prepare themselves for it by being particularly careful to be regular in sleep, exercise, and meals for some time before it. It is important that they should not do any work, either in

the day, or after active exercise. It would be good, however, for them to take a short walk in the fresh air before beginning, but they should go on no account into the examination room hungry or tired.

If they have a morning paper they should take care to be up in good time, and to have their breakfast over comfortably without hurry. They shouldn't work late at night, nor for more an hour in the evening altogether and give themselves a full rather than a short allowance of sleep. They should be in good time at their place, not too early least they should become nervous by waiting, nor too late for the fear of being flustered at the start. From three to five minutes before the time is sufficient to see that they have two or three good pens and to take their own if there is any fear that defective ones will be supplied. They should arrange their seat, inkstand, blotting paper, and watch conveniently for work. They should go over again their table of weights and measures just before going in. Above all things they should keep cool, read every question completely through before commencing to answer it, for the second part of the question often throw light upon the first. They should not crowd their work or be afraid of wasting paper.

If they aim at answering every question, they should divide the time by the number of questions and try to get each question done in its portion of time, saving time on the easier questions. In the early part of the paper they should not spend more than the proper time puzzling over a doubtful question unless they have already gained some time. They should not however, let this advice prevent them from going on with a solution they are in a fair way to finish.

If they come across a question which they know they cannot answer, they should not loose time in attempting it in vain, while there are other questions in the paper which they believe that they can do. They should not refrain however from answering a part of a question because they cannot answer the whole, for sometimes the second part is easier than the first. They should be accurate and careful in their work the first time in doing it, and have confidence in their own result.

After they have done all the straight-forward questions, they should look carefully at the rest of the paper, and select the easiest remaining question for trial. They should consider how they mean to attack it, write enough to indicate the method, briefly but clearly, and send this up at all events. Imperfect solutions often get considerable credit. It is a mistake to suppose that questions are arranged according to the order of the subject and a question on an advanced part of the subject may well be easier than one on the elementary part.

They should not be deterred from trying a question because it is a long one, for it is not always difficult on that account. The length of the question gives no hint as to the length of the answer. It is a pity to neglect an easy question though not reading it through. They should not think of leaving the room until time is called; so long as there is anything on the paper that they can possibly do, do not give in. If they have finished the paper, read over their work carefully, correct and supplement it.

In writing out proofs of rules and explanations of theory, they should remember that diffuseness wastes time and omission loses marks; the point to be aimed at is to put in everything essential as briefly as possible. In revising their work just before an examination, it is seldom wise to learn anything new; it is better to make sure of whatever they have known before.

HIGHER LOCAL EXAMINATION
Tuesday, June 17, 1873, 9 to 11 P.M.

1. Multiply three hundred and seventy-two million four hundred thousand and forty-six by itself and express the results in words.

2. Reduce to tenths of a penny the difference between five guineas and eighty-nine half crowns.

3. If 17 acres 3 roods and 33 poles cost £1236. 6s., how much will 50 acres 2 roods 21 poles cast at the same rate?

4. Find, by practice, the cost of 94 lbs 10 oz. 18 cwts. 6 grs. at £3 6s. 8d. per ounce.

5. Multiply together the sum and difference of $\frac{11}{18}$ and $\frac{5}{27}$ and divide the result by the product of $5\ \frac{1}{7}$ and $1\ \frac{31}{84}$.

6. Reduce $\frac{5}{256}$ to a decimal. What decimal of £5 is £12. 16s.? Find the value of 0.01625 of a ton, and shew that when divided by 0.0175 it becomes 18 cwts. 2 qrs. 8 lbs.

7. Find the interest on £875. 10s. for 3 ½ years at 5 per cent.

8. A cubic inch of gold is made to cover an acre of metal. Find the thickness of the gilding, and the weight of one square yard of it, assuming that gold is nineteen times as heavy as water, and that a cubic foot of water weights 1000 oz. Avoirdupois.

9. Reduce $\frac{11}{56}$ to a circulating decimal and $0.631\dot{8}$ to a vulgar fraction.

10. Extract the square root of 88.604569 and of $1+\frac{1}{9}+\frac{1}{4-\frac{1}{10}}$.

11. There are three speculations which bring in respectively 5, 7, and 9 percent on the money invested. Compare the average interest on their capitals obtained by two speculators, one of whom invests and equal sum in each, and the other invests such sums that he obtains equal income from each.

12. A person buys an article and sells it at a profit of 2s. 7d. On calculating his profit he finds that if he estimates it as a percentage on his outlay, it is one-fifth as great again as it would be if he estimated it as a percentage on the selling price. What did he give for the article?

13. The cost of a ton of coal in London is four times the cost at the pit's mouth, and half of the latter goes in the miners' wages. If a rise of 20 per cent in miners' wages be accompanied by a rise of 20 per cent of coals in London, what proportion of the cost of coals must have been due to carriage that the profits of those engaged in the coal trade may be only three times as great as before? (The cost of carriage is supposed to be unchanged), (University of Cambridge Higher Local Examination 1874).

In a speech given before the College of Preceptors on February 8, 1893, Hudson remarked that in teaching the fundamental law of pedagogy was "The understanding of the

pupil was to be employed throughout." (Hudson 1893). The correspondence to his arithmetic students illustrates his sound educational philosophy. Much of his pedagogical advice could well apply to other disciplines and many of his suggestions about preparing for exams are relevant today as they were then. It is not evident how many of his correspondence students passed the arithmetic examination, but thanks in part to Hudson and others like him, almost 70% of the women who took the Cambridge Higher Local Examination that June passed (University of Cambridge Higher Local Examination 1874).

Hudson belonged to a talented mathematical family. He was Third Wrangler on the 1861 Cambridge Mathematical Tripos. In 1882, he was appointed professor of mathematics at King's College London. A position he held until 1903. His wife Mary Watson (née Turnbull) matriculated at Newnham Hall in 1873 but did not sit for a tripos. Their son Ronald William Henry Turnbull Hudson of St. John's College was Senior Wrangler[8]on the 1898 Mathematical Tripos.[9] After a short career as a lecturer at University College, London, he died in a climbing accident in North Wales. Their eldest daughter, Winifred Mary, attended Clapham High School and was a Winkworth Scholar at Newnham College. She was bracketed with the Eighth Wrangler on the 1900 Mathematical Tripos. For most of her life, she worked part time for the Charity Organization Society. Hilda Phoebe attended Newnham College, and was bracketed with the Seventh Wrangler on the 1903 Mathematical Tripos. She spent a year at the University of Berlin and another at Bryn Mawr, before returning to Newnham as a lecturer. She was the only woman to give a communication at the 1912 International Congress of Mathematicians. In Cambridge, England. (Semple, 1969) During WWI, She worked on stress calculations for airplane structures for the Admiralty Air Department (Barrow-Green, 2014).

Newnham College was first established as a house in which women could reside while attending the Cambridge lectures. Hudson and other supporters of the enterprise formed a limited company to raise funds, lease land, and set a course of study in preparation for examinations. In 1875, the first buildings were constructed. The Newnham Hall Company and the Newnham College Association joined in 1880 to form Newnham College.

Girton College had opened its doors in 1873, providing women two opportunities for undergraduate education in Cambridge. The lectures for ladies were subsumed by the colleges while the correspondence courses continued until the 1890s.

REFERENCES

Barrow-Green, J., (2014). Cambridge Mathematicians' Responses to the First World War. In D. Aubin, & C. Goldstein (Eds.), *The War of Guns and Mathematics*, (p. 80). Providence: American Mathematical Society.

Hudson, W. H. H. (1872a). Instruction by Correspondence, *Newham College Archives*, EC/2/3/2.

Hudson, W. H. H., (1872b). Questionnaire, *Newnham College Archives*, EC 2/3/2.

Hudson, W. H. H., (1872-73). Circular letter #1(14 October), #2 (22 October), #3 (7 November), #4 (6 January), #5 (1 May), *Newnham College Archives*, EC 2/3/2.

Hudson, W. H. H., (1873). Circular letter #6 (21 May), *St. John's College Archives* 12/15/71.

[8] The examination for an honours degree at Cambridge. The person who ranked first on the exam was the Senior Wrangler, the person next was called the Second Wrangler, and so forth. The person who ranked last for an honours degree was referred to as the Wooden Spoon.

[9] The physicist James Jeans was Third Wrangler and the mathematician G.H. Hardy was Fourth Wrangler.

Hudson, W. H. H., (1893). The teaching of mathematics. *Educational Times 46*, p. 138.
Measuring worth (n.d.). Online at www.measuingworth.com. Accessed 14 February 2019.
Semple, J. G., (1969). Hilda Phoebe Hudson, *Bulletin of the London Mathematical Society*, *1*, 357-359.
University of Cambridge Higher Local Examination 6th Annual Report (1874), *St John's College, Cambridge Archives*, 12/15/71.