CASE #17

Personalizing the History of Mathematics through Institution-Specific Archival Materials

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LEARNING OBJECTIVES ENGAGED FROM *GUIDELINES FOR PRIMARY SOURCE LITERACY* BY THIS CASE STUDY

3.A. Examine a primary source, which may require the ability to read a particular script, font, or language, to understand or operate a particular technology, or to comprehend vocabulary, syntax, and communication norms of the time period and location where the source was created.

3.B. Identify and communicate information found in primary sources, including summarizing the content of the source and identifying and reporting key components such as how it was created, by whom, when, and what it is.

4.B. Critically evaluate the perspective of the creator(s) of a primary source, including tone, subjectivity, and biases, and consider how these relate to the original purpose(s) and audience(s) of the source.

4.C. Situate a primary source in context by applying knowledge about the time and culture in which it was created; the author or creator; its format, genre, publication history; or related materials in a collection.

4.F. Demonstrate historical empathy, curiosity about the past, and appreciation for historical sources and historical actors.

CASE STUDY LOCATION

Norwich University
Northfield, Vermont
https://www.norwich.edu/

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Introduction and Institutional Context

Norwich University, founded in 1819 by Captain Alden Partridge, is the oldest private military college in the United States. The Norwich University Archives and Special Collections, housed in the library, include more than "2,100 boxes of written records and still photographs relating to the history of Norwich University, its staff, students and alumni."[1] Some university instructors (primarily in the humanities and social sciences) plan for their classes to visit the University Archives for a particular research project or exploration of primary sources once during a semester. It is also common to see students completing an assignment in the archives, using the archivists as instructors and resources for a class research project, without any professorial oversight.

In order to expand teaching opportunities using archival materials at the university, the staff of the Norwich Archives have made concerted efforts to empower faculty members to familiarize themselves with the archives and use the collections in their teaching. After an impressive renovation of the university library in 2015, two library classrooms were made available to faculty through a competitive application process based on innovative use of new teaching technologies and library resources. Norwich archivists asked that the Archives Instructional Room (AIR) also be available for an entire semester of course use by application to the University Library Committee, with the added requirement that archival materials be used in at least two class meetings. As other classrooms around campus have been renovated, the Semester Course Use Award process has been discontinued, and applications to teach in the AIR are now considered on a case-by-case basis by the archives staff. In addition to welcoming faculty into the archives through the Semester Course Use Award, faculty use of the archives is promoted at Norwich through the Caraganis Prize for Teaching with the University Archives.[2] The purposeful work Norwich's archivists have done to increase faculty use of the archives has led to a shift in many cases in the teaching responsibilities from the archivists to the faculty members, putting the archivists in a key supporting role in the University Archives education program.

In Fall 2016, MA 399: History of Mathematics received a Semester Course Use Award to be taught in the AIR. This junior-level special topics course—the first history of mathematics course taught at Norwich University—was an upper division elective which math majors could use toward graduation credits. Although this was Norwich's first history of mathematics course, the instructor/author had prior experience teaching such a course using activities and hands-on explorations, considering mathematics as a human endeavor by focusing on historical context and mathematicians as people, and exploring mathematical problems the way people of the past would have experienced them.[3] Recognizing the importance of original sources to engage students in mathematics, in the past the instructor has utilized collections of primary sources for the exploration of the history of mathematics such as Katz, MAA Convergence, and Stedall.[4] The integration of Norwich-specific primary sources became a natural

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1 Norwich University Archives and Special Collections, "FAQs," accessed February 11,2021, https://archives.norwich.edu/digital/custom/faqs/.

2 Norwich University, "Caraganis Prize for Teaching with the University Archives," accessed February 11, 2021, https://guides.norwich.edu/services/faculty-support/caraganis.

3 Christine Latulippe, "An Activities-based History of Mathematics Course for Preservice Secondary Teachers," in *The Course of History: Ideas for Developing a History of Mathematics Course*, ed. Amy Shell Gellasch and Dick Jardine (Washington, DC: Mathematical Association of America, 2018), 129–143.

4 Victor J. Katz and Karen Dee Michalowicz, *Historical Modules for the Teaching and Learning of Mathematics* (Washington, DC: Mathematical Association of America, 2005); MAA Convergence, "Index to Mathematical Treasures," accessed February 11, 2021, https://www.maa.org/press/periodicals/convergence/index-to-mathematical-treasures; and Jacqueline Stedall, *Mathematics Emerging: A Sourcebook 1540–1900* (Oxford: Oxford University Press, 2008).

extension of the instructor's previous pedagogical efforts, and a creative way to engage students in mathematics as a human endeavor. Two of the primary course goals for MA 399 were to emphasize the "who" of the history of mathematics to help students understand mathematics as a human endeavor, and to have students solve problems the way earlier mathematicians did. These goals guided the instructor's consideration of each artifact offered by the head archivist, and could be met in a variety of ways. Clear goals and experience allowed the instructor to see possibilities and be innovative using archival materials to flexibly address particular learning objectives.

While addressing specific mathematical objectives, teaching MA 399 in the University Archives and Special Collections also allowed for students to engage with the following Learning Objectives from the *Guidelines for Primary Source Literacy*. These Learning Objectives aligned naturally with the existing mathematical objectives and structure of the course as well as with the relevant artifacts available.

- 3.A. Examine a primary source, which may require the ability to read a particular script, font, or language, to understand or operate a particular technology, or to comprehend vocabulary, syntax, and communication norms of the time period and location where the source was created.
- 3.B. Identify and communicate information found in primary sources, including summarizing the content of the source and identifying and reporting key components such as how it was created, by whom, when, and what it is.
- 4.B. Critically evaluate the perspective of the creators of a primary source, including tone, subjectivity, and biases, and consider how these relate to the original purpose(s) and audience of the source.
- 4.C. Situate a primary source in context by applying knowledge about the time and culture in which it was created; the author or creator; its format, genre, publication history; or related materials in a collection.
- 4.F. Demonstrate historical empathy, curiosity about the past, and appreciation for historical sources and historical actors.

One Particular Box: The Alonzo Jackman Papers

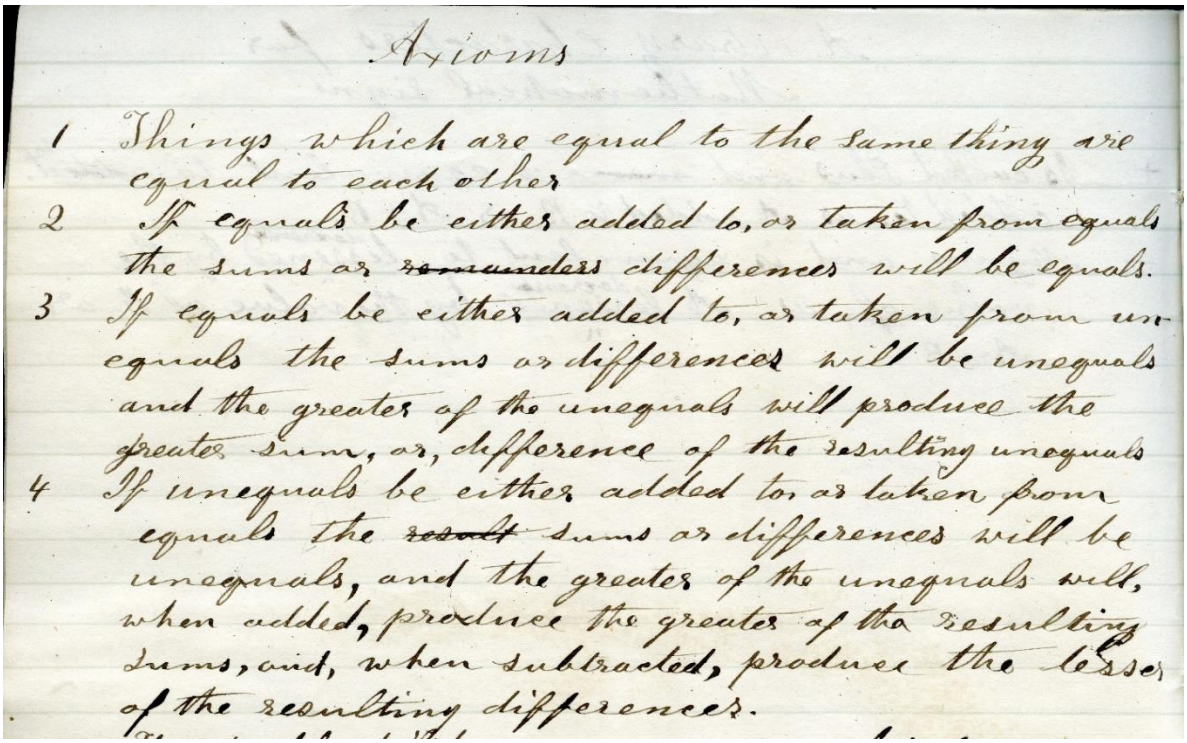
The overall course structure for MA399 was a survey of the history of mathematics, exploring topics in the history of numbers, geometry, and algebra, across time and place. It made sense to expand these topics to include archival materials as relevant, making the course more Norwich-specific, and personal to students, and so the instructor initiated a conversation with the Head of Archives and Special Collections before applying to teach in the archives. Norwich's head archivist saw pedagogical potential in the Alonzo Jackman Papers and was eager to have a STEM faculty member explore them and find their classroom relevance. An 1836 Norwich alumnus, Alonzo Jackman was a professor of mathematics, civil engineering, drawing, military science, and tactics at Norwich University for most years between 1837 and his death in 1879. The instructor's initial review of the finding aid and Jackman's papers made it clear that Jackman's work in geometry alone would allow for the incorporation of at least the required two days of archival materials into the course.

After being accepted to teach MA 399 in the archives, the instructor took time to more thoroughly research the Alonzo Jackman Papers and think deeply about which materials would fit best into the course. The instructor used an iterative process, planning the course broadly around the minimum required two days of using archival materials, and then revisiting the Jackman files and talking with the

head archivist throughout the course, finding more opportunities to use archival materials in teaching the history of mathematics. The head archivist knew the content of the University Archives and Special Collections, suggesting resources, and then supporting the faculty member to "determine which collections animate students, support course objectives, and are appropriate for student levels of skill," as described by Doris Malkmus.[5] With the head archivist's expertise and guidance, the instructor felt comfortable learning and exploring the physical and digital archives, and adapting class usage of archival materials as she saw how students were responding to the overall course material. The Norwich University archivists deliberately promote this type of teaching relationship, where the course remains the faculty member's responsibility.

Narrative

The introduction to archival materials began with a day for the head archivist to come to class and explain the transcription process and the handling of archival materials to MA 399 students. This was the only day when the head archivist directly taught the MA 399 course, using a video about captions to emphasize the importance of human intelligence in the transcription process.[6] Each MA 399 student was provided a high-quality photocopy of a page from one of Alonzo Jackman's mathematical notebooks that is related to the axioms posited in Euclid's *Elements.*[7]



Axioms

1 Things which are equal to the same thing are equal to each other

2 If equals be either added to, or taken from equals the sums or ~~remainders~~ differences will be equals.

3 If equals be either added to, or taken from unequals the sums or differences will be unequals and the greater of the unequals will produce the greater sum, or, difference of the resulting unequals

4 If unequals be either added to or taken from equals the ~~result~~ sums or differences will be unequals, and the greater of the unequals will, when added, produce the greater of the resulting sums, and, when subtracted, produce the lesser of the resulting differences.

Figure 1: Alonzo Jackman's 'Axioms', no date.

[5] Doris J. Malkmus, "Primary Source Research and The Undergraduate: A Transforming Landscape," *Journal of Archival Organization* 6, no. 1-2 (2008): 47–70, https://doi.org/10.1080/15332740802235125.

[6] Rhett and Link, "CAPTION FAIL: Jamaican Vacation Hoax," February 11, 2011, https://www.youtube.com/watch?v=23H8IdaS3tk.

[7] Mathematics Notebooks of Alonzo Jackman, undated, Alonzo Jackman Papers, Mathematical Calculations and Writings, Folder 51, Norwich University Archives, Kreitzberg Library, Northfield, VT.

The original artifact was in the room for examination, and a number of Jackman's other mathematical notebooks were also available for students to look through and try to make sense of. This was just one of Alonzo Jackman's collection of notebooks, which are a charming variety of recycled formats, shapes, and sizes. In contrast, today's students type notes on a laptop computer, or buy a set of matching notebooks at the store. Cursive handwriting is both intriguing and difficult for students to work with, considering that some students have not learned it in their own schooling. Although not completely overcome in a day's lesson, the transcription activity provided students with practice of close reading, interpretation and analysis of cursive, as well as the mathematical content of the artifact (learning objective 3.A.). This hands-on activity and subsequent class discussion put into context the class's physical location in the Archives Instructional Room for the semester, one element of the work of an archivist, and the unique nature of the MA 399 course.

Contextualizing Jackman's Work

Unlike many courses that visit the archives, MA 399 did not use the archives for students to practice research skills with primary sources, but instead employed the archives to provide a personal context for understanding the history of mathematics and encourage students' curiosity about the past (learning objective 4.F.). In 1872, Alonzo Jackman published, and had copyrighted by the Library of Congress, a paper demonstrating a seemingly satisfactory method for squaring the circle, which is to construct a square having an area equal to that of a given circle using only compass and straightedge. Squaring the circle is one of three famous geometric construction problems of antiquity, the others being to trisect an angle, and construct the edge of a cube having twice the volume of a given cube.[8] MA 399 students spent four class days exploring Jackman's work on squaring the circle, a problem which has also been investigated by—or mentioned in work by—the Rhind Papyrus, Aristotle, Archimedes, Johann Bernoulli, and Srinivasa Ramanujan.[9]

The instructional sequence began with a class period creating geometric constructions with compass and straightedge, which some students had no prior experience with; this hands-on exploration provided familiarity with and understanding of the tools available for ancient and pre-computer geometers. MA 399 students next spent two days examining Jackman's work on squaring the circle, including his article and its revisions,[10] and a biography of Alonzo Jackman written by a Norwich student (F.W. Bartlett) for the school newspaper, the *Reveille*, published in 1884. The instructor conducted online archival research in order to present biographical background on Alonzo Jackman including photographs, and the historical context of the *Reveille* where the biography was published. This particular *Reveille* was published during a five-year span when Norwich University was named Lewis College because of a generous donation given to the school during hard times by alumnus and Trustee Charles Lewis; some students knew about this historical sidenote, and others did not. This aside was one of many attempts by the instructor to provide MA 399 students with context and possible points of

[8] Sanderson Smith, *Agnesi to Zeno: Over 100 Vignettes from the History of Math* (Berkeley, CA: Key Curriculum Press, 1996).

[9] MacTutor History of Mathematics Archives, "Squaring the Circle," accessed February 11, 2021, https://mathshistory.st-andrews.ac.uk/HistTopics/Squaring_the_circle/.

[10] *The Circle Squared*, 1872–1876, Alonzo Jackman Papers, Mathematical Calculations and Writings, Folder 44, Norwich University Archives, Kreitzberg Library, Northfield, VT.

connection for their own understanding of the ideas being discussed, supporting learning objectives 4.C. and 4.F., and discussed in literature about using primary sources in the mathematics classroom.[11]

Many students are not proficient at reading even modern mathematics textbooks, so in an effort to not overwhelm students with the density of Alonzo Jackman's *The Circle Squared,* the assignment was to skim and observe. *The Circle Squared* is a published and typeset work, of which the archives holds multiple copies (four of the 1872 original and eight copies of subsequent revisions[12]) which students were able to examine independently. To ease into the reading, the instructor provided a brief review of geometric notations or definitions, anticipating that students could access the mathematical material with a little prompting. Encouraging the practice of learning objectives 3.A. and 3.B., while reading independently students were asked to make notes of the following:

- What symbols, words, diagrams do you understand?
- What symbols, words, diagrams do you not understand?
- Pick a paragraph (or sentence!) and describe the general meaning or idea

At the end of students' independent reading, the class shared observations regarding what students understood and didn't understand.

The following class period, MA 399 students examined copies of an 1882 *Reveille* article in which student J. B. Johnson reviewed Jackman's work squaring the circle, and defended Jackman's honest attempts at solving this problem.[13] This particular artifact developed student awareness of looking at mathematics in the appropriate historical context as opposed to through a modern lens (learning objectives 4.B. and 4.C.); in 1872 when Jackman wrote *The Circle Squared*, squaring the circle was a worthy problem to pursue.[14] Students again were asked to read loosely and notice the tone of Johnson's writing, symbols they understood, and areas of confusion. In 1882, ten years after Jackman's original article was published, squaring the circle with only a compass and straightedge was proven to be impossible, due to a proof by Ferdinand von Lindemann that the number pi (π) is transcendental. The four-day MA 399 investigation closed with a lesson on transcendental numbers, the two most famous of which are e and π. This instructional sequence allowed for reflection on perseverance in mathematics, including problems which have puzzled mathematicians for many generations (e.g., squaring the circle and Fermat's Last Theorem) and illustrated the concept of true mathematical proof. It also challenged students to make connections with their other mathematics courses and content previously learned.[15]

Outside of The Box: Expanding the Use of the Archival Collections

Initially, the planned use of archival materials involved only the Alonzo Jackman Papers. However, partway through the academic term, Norwich's head archivist shared a file with the instructor which yielded further learning opportunities for MA 399 students. Alden Partridge was the founder of Norwich

[11] Hans Niels Jahnke et al., "The Use of Original Sources in the Mathematics Classroom," *History in Mathematics Education*, eds. John Fauvel and Jan van Maanen (Springer, Dordecht, 2002), 291–328, https://doi.org/10.1007/0-306-47220-1_9.

[12] *The Circle Squared*, Alonzo Jackman Papers, Folder 44.

[13] J.B. Johnson, "Square of the Circle." *Lewis College Reveille*, April 1882, Volume 1, Issue 4, Norwich University Archives, Kreitzberg Library, Northfield, VT.

[14] Jahnke et al., "The Use of Original Sources."

[15] Uffe Thomas Jankvist, "A Categorization of the 'Whys' and 'Hows' of Using History in Mathematics Education," *Educational Studies in Mathematics* 17, no. 3 (2009): 235–261.

University, and the instructor recognized a collection of mathematics exams from his students from 1822 to 1824 as relevant to the history of algebra unit of the MA 399 class, during which the class explored rhetorical, syncopated, and symbolic algebra. These exams were essentially half-sheets of notebook paper, each with a problem written by hand, and then solved. The MA 399 class transcribed and solved two different example problems together with the instructor, placing the original artifact under the document camera for the whole class to view simultaneously. In this case, transcribing the problems rather than just reading the documents slowed students down, fostering close reading, participatory learning, and critical thinking. Those readers familiar with mathematics will notice that the example problem below, written by student Almon Mack, can be solved with a system of two linear equations (roughly high school algebra level mathematics).[16] For many MA 399 students, the process of translating from cursive handwriting to modern writing, and then from words to appropriate mathematical symbols was more difficult than the mathematics of solving the problem, also noted in Barnett, Lodder, and Pengelley.[17]

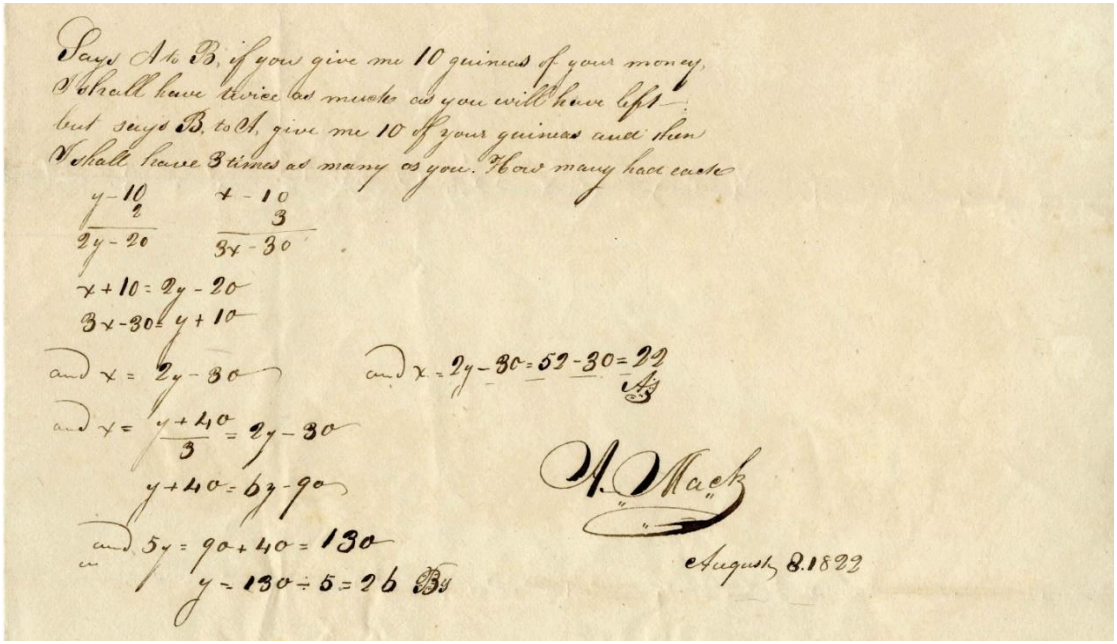


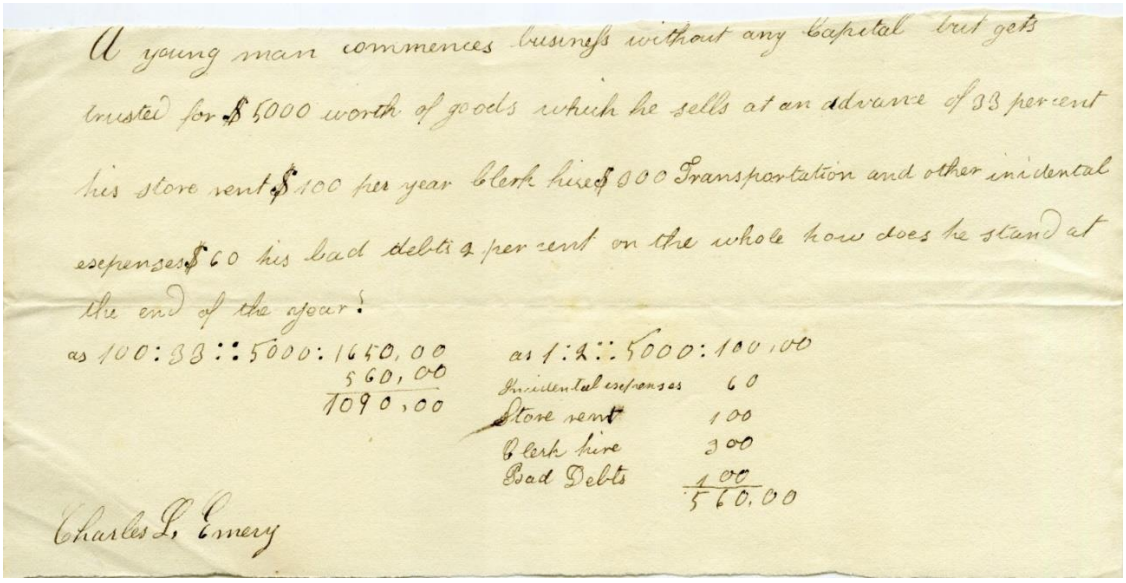
Figure 2: Exam paper from Almon Mack, Norwich University Cadet from Norwich, Vermont, 8 August 1822.

After practicing the transcription and solving process together, each MA 399 student received their own copy of one particular problem that there were fourteen different versions of from Alden Partridge's students. Two examples are provided in Figures 3 and 4.[18]

[16] Student mathematics examination of A. Mack, 8 August 1822, Alden Partridge Records, Box 1, Mathematics, student examinations, 1822–1824 file, Norwich University Archives, Kreitzberg Library, Northfield, VT.

[17] Janet Heine Barnett, Jerry Lodder, and David Pengelley, "The Pedagogy of Primary Historical Sources in Mathematics: Classroom Practice Meets Theoretical Frameworks," *Science and Education* 23, no. 1 (2014): 7–27, https://doi.org/10.1007/s11191-013-9618-1.

[18] Student mathematics examinations of C. Emery and J. French, Alden Partridge Records, Box 1.



A young man commences business without any capital but gets trusted for $5000 worth of goods which he sells at an advance of 33 per cent his store rent $100 per year clerk hire $300 Transportation and other incidental escpenses $60 his bad debts 2 per cent on the whole how does he stand at the end of the year?

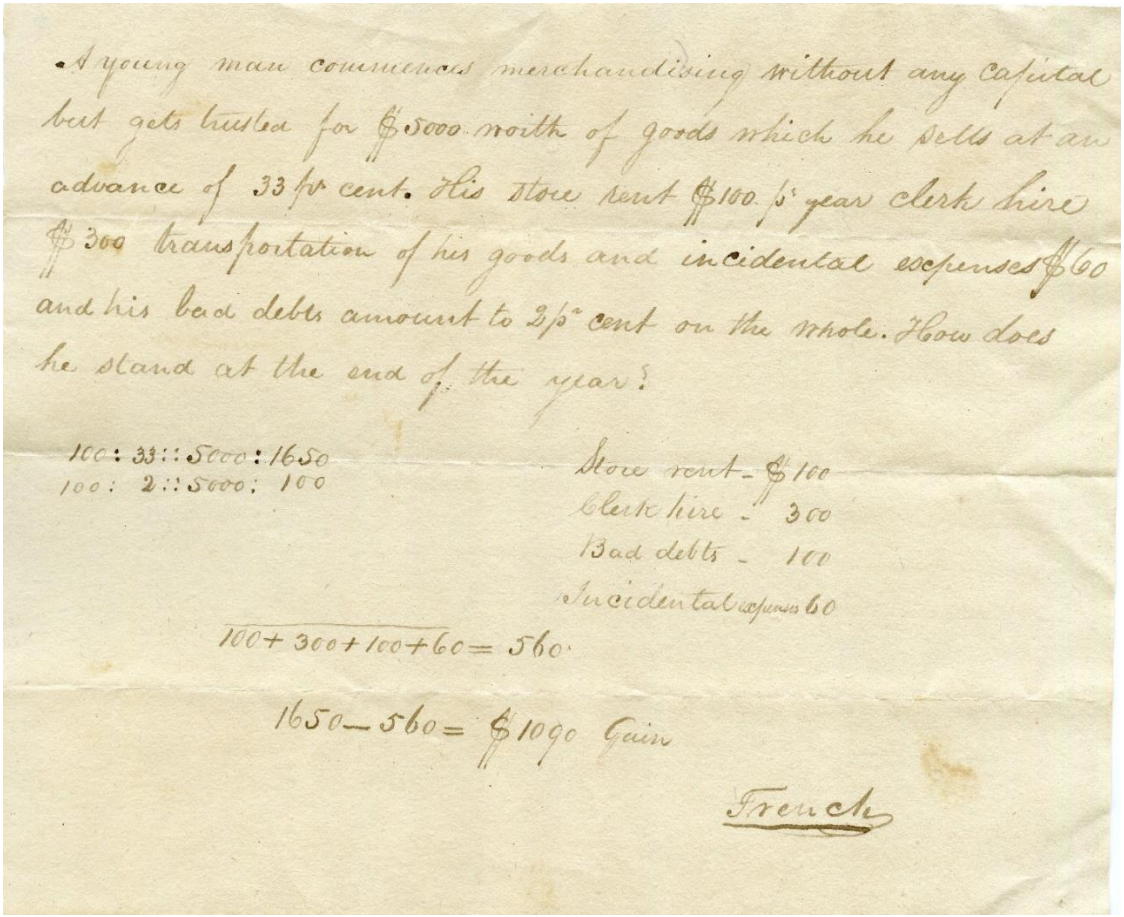
as 100 : 33 :: 5000 : 1650,00
560,00
1090,00

as 1 : 2 :: 5000 : 100,00

Incidental expenses	60
Store rent	100
Clerk hire	300
Bad Debts	100
	$560.00

Charles L. Emery

Figure 3: Exam paper from Charles Emery, Norwich University Cadet from Concord, New Hampshire, no date.



A young man commences merchandising without any capital but gets trusted for $5000 worth of goods which he sells at an advance of 33 p^r cent. His store rent $100 p^r year clerk hire $300 transportation of his goods and incidental escpenses $60 and his bad debts amount to 2 p^r cent on the whole. How does he stand at the end of the year?

100 : 33 :: 5000 : 1650
100 : 2 :: 5000 : 100

Store rent - $100
Clerk hire - 300
Bad debts - 100
Incidental expenses 60

100 + 300 + 100 + 60 = 560

1650 − 560 = $1090 Gain

French

Figure 4: Exam paper from James French, Norwich University Cadet from Sandwich, New Hampshire, no date.

MA 399 students rewrote the problem in their own handwriting, solved the problem using whatever modern methods they chose, and then compared their solution process to that of Alden Partridge's student. MA 399 students were able to compare their transcription with classmates, and with the few extra versions of the problem available.

While solving the problems of Partridge's students, MA 399 students were tasked to consider the following questions:

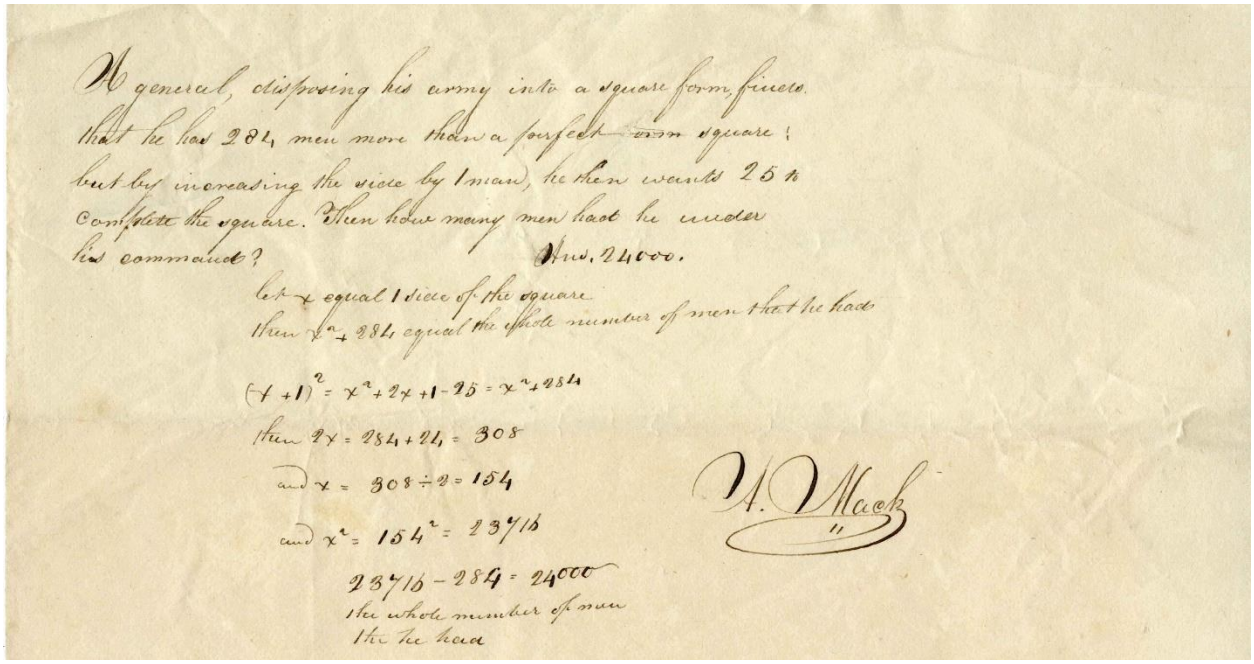
- What characteristics might the 1820s Cadets have that would allow them to relate to these problems?
- How do these problems and their solutions compare to how math is presented today?
- What notation do you recognize? What notation is unusual to you?

Also available for when students lost focus on the primary source they were examining, the instructor had printed copies of Norwich Catalogues from 1821, 1822, 1823 from the online Norwich Archives. These catalogues listed current students' names and home towns, allowing MA 399 students to form more personal connections with the original writers of the problems they were transcribing and working on. The presence of the catalogues and the question prompts provided put the Partridge exam problems into familiar context and encouraged MA 399 students to consider the time and space Partridge's students occupied. This activity sequence supported learning objectives 3.A., 4.C., and 4.F.

Using Archival Collections for Assessment

While considering which of Alden Partridge's student examination papers should be shared with MA 399 students, the instructor was excited to see a problem from a 1557 text (Robert Recorde's *The Whetstone of Witte*) about a general placing his army into a square formation. This context seemed particularly relevant to past and current students at a military college, and is a problem the instructor was familiar with and had planned on including on the final exam for the course, even before knowing about Alden Partridge's students' examinations. Norwich's head archivist created a high-quality scan of the artifact for its inclusion on the final exam for the course, rather than the instructor simply type-setting the question. Inclusion of this image on the exam continued the MA 399 emphasis on learning objectives 3.A. and 3.B.

> **From the MA 399 Final Exam:**
>
> The following problem is originally found in Robert Recorde's *The Whetstone of Witte*, 1557. The copy here was written in 1822 by Almon Mack, a student of Alden Partridge.
>
> a. Transcribe the problem—write it out in your own handwriting.
>
> b. Solve the problem.


A general, disposing his army into a square form, finds that he has 284 men more than a perfect square; but by increasing the side by 1 man, he then wants 25 to complete the square. Then how many men had he under his command? Ans. 24000.

Let x equal 1 side of the square
Then $x^2 + 284$ equal the whole number of men that he had

$(x+1)^2 = x^2 + 2x + 1 - 25 = x^2 + 284$

Then $2x = 284 + 24 = 308$

and $x = 308 \div 2 = 154$

and $x^2 = 154^2 = 23716$

$23716 - 284 = 24000$
the whole number of men
that he had

A. Mack
"

Figure 5: Exam paper from Almon Mack, Norwich University Cadet from Norwich, Vermont, 8 August 1822.

Results

MA 399: History of Mathematics was a natural course to host in the Norwich University Archives, which are home to an abundance of materials related not just to the humanities and social sciences but to mathematics and science as well. Spending a semester in the archives allowed for the telling of intertwined stories about mathematics, history, and Norwich University. Norwich's rural location makes other archives and original primary sources nearly impossible to access, but the University Archives are home to a wide range of resources which encourage hands-on learning, and engage students with academic content past and present.

Teaching the history of mathematics course in the Norwich University Archives allowed for a group of undergraduate mathematics majors to interact with primary mathematical sources as a tool for learning about the history of mathematics. Although there was no formal assessment of the use of the University Archives to teach the history of mathematics, anecdotally, MA 399 students described an added benefit of attending class in the archives was an increased comfort with the archives for subsequent research projects in history and English courses, echoed in Malkmus.[19] Students also felt that the MA 399 course helped connect them to Norwich and the university's history and mission in positive and unexpected ways (learning objective 4.F.). This feedback was gained through in-class discussions, as well as student testimonies during a presentation to the Board of Trustees about the MA 399 course. In the future, student perception surveys could provide more in-depth information about achievement of both the course's mathematical and primary source literacy learning objectives.

[19] Malkmus, "Primary Source Research."

Lessons Learned

Although the MA 399 instructor had not visited the Norwich University Archives and Special Collections before designing the course, she is now an ambassador for the use of Norwich's Archives. Norwich's head archivist referred to herself as a "guide on the side," providing a great deal of support as the instructor made connections between available artifacts and course content, and looked for supporting materials to help students make sense of time and place as they related to highlighted primary sources. The welcoming atmosphere and productive collaboration with the archivists, in addition to the vast array of mathematical resources awaiting course integration are something that more Norwich University faculty would benefit from knowing about.

Having used published facsimiles of primary sources for many years, the instructor noticed, anecdotally, a higher level of student engagement with learning objectives 3.A., 3.B., and 4.C. while teaching in the archives than in the past. In the future, if not able to be physically situated in the University Archives and Special Collections, the instructor would opt to teach with digital copies of Norwich primary sources over the use of digital copies of more famous primary sources from the history of mathematics. Through the use of both in the same semester, it appeared that student engagement with learning objectives 4.B., 4.C., and 4.F. was greatly enhanced through the use of Norwich-specific primary sources, as compared with works of distant mathematicians like Leonhard Euler.

Acknowledgements

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