SPECIAL SECTION: ARCHIVES AND EDUCATION

STEM Undergraduates and Archival Instruction: A Case Study at NYU Polytechnic School of Engineering

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ABSTRACT

STEM undergraduates are an underserved population in archival outreach and instruction. This case study, conducted at New York University's Polytechnic School of Engineering using the Poly Archives and Special Collections at Bern Dibner Library, aims to demonstrate the benefits of integrating archival research into the undergraduate STEM curriculum. Archivist and faculty collaboration during a semester-long course not only resulted in student gains in archival intelligence, but also allowed students to practice critical thinking, reasoning about uncertainty, and working collaboratively in teams, all competencies recognized as integral to engineering design and the Accreditation Board for Engineering and Technology's guidelines for developing engineers for the twenty-first century.

KEY WORDS

Collaboration, College and university archives, Introduction to archives, Scientific records

In a time of economic uncertainty and rising student loan debt in the United States, STEM (science, technology, engineering, and math) education is increasingly viewed as a path to success and financial stability. From media reports praising the value of a STEM degree, to President Obama's Educate to Innovate Initiative,[1] STEM students and educators are attracting substantial awareness both within popular culture and higher education. Despite this attention, archival outreach efforts often overlook STEM undergraduates. This oversight is twofold: archivists, particularly those at science and engineering libraries, need to actively engage this underserved user population, while STEM faculty need to recognize the cognitive and practical gains archival and primary source research can provide for their students.

A few potential obstacles stand in the way of faculty-archivist collaboration in STEM higher education. For one, science and engineering faculty may not be aware of archival connections to engineering instruction and may be skeptical of how archival instruction and research could aid their students. While the archives are regarded as the "laboratory of the humanities,"[2] scientists and engineers focus on their own specialized laboratories and textbook-heavy prerequisite courses. Second, given the rigorous number of required courses and labs STEM students must complete to graduate, faculty may hesitate to integrate new elements into the curriculum. Finally, the structure of the faculty reward system at many universities recognizes research productivity over contributions to undergraduate education, which encourages faculty to focus more on their own research than on undergrad course design.

A relatively recent shift in thinking about how best to educate engineers for the twenty-first century may help to mitigate some of these potential barriers to archivist-faculty collaboration. Beginning in the 1990s, the revised United States engineering and technology program accreditation criteria encourage a departure from the "engineering science" model of instruction,[3] which emerged in the 1950s, and a move toward a more holistic education, which stresses understanding engineering concepts in a global and societal context, the development of divergent-convergent thinking, the ability to work and communicate within multidisciplinary groups, and the ability to engage in lifelong learning.[4]

The following case study of a course conducted at the New York University Polytechnic School of Engineering demonstrates how integrating archival instruction and research into the STEM curriculum can have positive learning outcomes, including those outcomes specifically designated as advantageous for successful STEM students and professionals by the Accreditation Board for Engineering and Technology (ABET).

Literature Review

Efforts to engage undergraduates in primary source research have increased since the 1990s, but there are often roadblocks to the successful integration of archival research into the curriculum.[5] Even when case studies highlight the use of primary source research in undergraduate studies, the courses surveyed are invariably in the humanities.[6] A 2008 survey of 370 Society of American Archivists (SAA) members revealed that while other academic departments, such as journalism, sociology, and political science, may request archival instruction, the number of requests is far lower than those from history and English departments.[7] Although some respondents cited contact with history of science, mathematics, engineering, and architecture departments in their comments, these departments were not listed in the table titled "Disciplines Requesting Instruction," indicating that these represented singular or very infrequent requests.[8]

Besides a lack of requests from nonhumanities departments, archivists themselves are reluctant to introduce primary sources to classes outside of the history department. During a 2009 New England Archivists session, "[a] common theme was that participants did not feel that their holdings included the types of materials that lent themselves to teaching. Most of this stemmed from an assumption that the only courses where archives were relevant were history classes."[9] Although many archivists recognize the importance of introducing undergraduates to primary source research, the STEM undergraduate community often remains overlooked.

The biggest obstacle facing archivists who attempt outreach to faculty and students at engineering schools is the rigid structure of engineering education, which has been in place in the United States since the 1950s.[10] In this model, students begin with two years of foundational math and science courses. Only after tackling advanced math and science theory do they move on to thinking about practical design projects and real-world technological problems.[11] In the last fifteen years, the engineering education literature has acknowledged that, while this was considered the "traditional" engineering education model, it is important to recognize that prior to the creation of engineering schools in the late nineteenth and early twentieth centuries, engineering was taught under an apprenticeship model in which students learned by doing.[12] This acknowledgment has sparked a renewed interest in curricular changes to require engineering and technology students to perform hands-on design and laboratory experiments earlier in their academic careers.[13] Working in the laboratory or on a design project are both examples of project-based learning, which requires students to experiment with ideas and procedures, to analyze data, to develop strategies for handling uncertainty and tolerating ambiguity, to demonstrate creativity, to acquire sensory awareness of materials, to work in collaborative groups, to learn from failure, and, ultimately, to understand the iterative process of research.[14]

Engineering education literature has also focused on how to rectify competency gaps produced by the twentieth-century engineering education model to create engineers for the twenty-first century. In a 2000 study addressing these nontechnical competency gaps, professors at Illinois State University argued that "technicians are no longer limited to narrow, specialized roles" and are instead expected to "possess cross-functional inter-disciplinary knowledge, skills, and attitudes."[15] Their study found that many of these competency gaps are due to three main curricular shortcomings in STEM education:

> One, traditional engineering and technology accreditation standards are so prescriptive that students do not have the time and are not required to take a sufficient number of general education classes. Two, many faculty use accreditation standards as a reason for not changing and updating course materials. As a third factor, individual faculty members have a difficult time integrating non-technical/engineering concepts into their course materials and student experiences.[16]

Subsequently, the ABET criteria were updated to include a more comprehensive matrix of skills and competencies focusing on student outcomes, including analysis and interpretation of data; the ability to function on multidisciplinary teams; the broad education necessary to understand the impact of engineering in a global, economic, environmental, and societal context; the ability to communicate effectively; and a recognition of the need for, and an ability to engage in, lifelong learning.[17] As a result, some engineering faculty are thinking of ways to design learning experiences that promote "the broader cognitive, social, affective, and psychomotor development required of today's engineering graduate."[18]

One of these proposals is the Four-Domain Development Diagram (4DDD), which uses a causal loop diagram as a model to represent learning goals, relationships, and student outcomes to guide engineering course design toward strategically targeting the ABET criteria. In a study using 4DDD in a course, which was team-taught by a materials engineering professor, a biology professor, and a librarian, thirty-two STEM students were required to read primary and secondary sources on their own and then to work in teams of six on projects in which they had to make connections and defend ideas, based on their readings, through debate or presentations. At the end of the course, students reported "a higher level of self-regulated learning, specifically, reading assigned journal articles, in preparing prior to class compared to their other courses."[19] Students also reported that working in teams helped them to see the "bigger idea" by hearing different points of view and that the challenge of fielding questions with no right or wrong answers helped to support "systems thinking."[20] While archivists should recognize these competencies as skills that can be gained through archival research, the challenge exists in how to convey this idea to STEM faculty successfully. For archival research in STEM curricula to produce a positive learning experience, the professor and the archivist must work together to determine the course structure and objectives.

The first hurdle to integrating archival research into an undergraduate classroom is to make the professors and students aware that archives and special collections exist within their university library.[21] If this introduction happens at all, it is often conducted as a brief orientation session followed by show-and-tell rather than an in-depth exploration of the collections.[22] While this superficial exposure is better than nothing, it does not actually teach students much about the purpose of archives or how the students might go about conducting primary source research on their own. The trend toward expanding one-time instructional sessions into a curriculum-based approach has been on the rise in recent years, in part thanks to Elizabeth Yakel and Deborah Torres's 2003 article,[23] which defined a set of "archival intelligences" patrons must develop to effectively conduct archival research.[24]

Yakel and Torres interviewed twenty-eight archives and special collections patrons to determine a set of three distinct forms of knowledge required to work effectively with primary source materials. These forms of knowledge, which together the authors call "archival intelligence," include "1) knowledge of archival theory, practices and procedures; 2) strategies for reducing uncertainty and ambiguity when unstructured problems and ill-defined situations are the norm; 3) and intellective skills."[25]

The first principle of archival intelligence is the most basic—to use primary source materials, the patron must first know how to find relevant materials by understanding how to locate collections, how to gain access to the collections, and how collections are arranged.[26] Gaining familiarity with the rules is an important part of archival intelligence because "once the rules are learned, a researcher can devote more mental resources to thinking about the research problem and to developing specific archival research strategies."[27]

The second dimension of archival intelligence involves being able to cope with the inevitable archival silences and dead ends in primary source research and to develop strategies for reducing uncertainty and managing unstructured problems.[28] An unstructured problem, the basis of many archival (and technological) inquiries, is defined as a problem that has "one or more parameters the values of which are left unspecified as the problem is given to the problem solving system."[29]

Yakel and Torres call the third component of archival intelligence "intellective skills." By this they mean "the ability to understand representations of documents, activities, and processes."[30] Part of this process is planning ahead to identify potential collections, looking through online finding aids, and scheduling adequate time to work with materials in the archives. The experienced researcher will develop strategies for sorting through a collection and will be able to understand the representational relationship between primary source documents and surrogates within the collection.[31]

Yakel and Torres concluded their analysis of archival intelligence with the acknowledgment that developing these skills is difficult and takes time. While they understand that archivists may not be able to help all researchers in all three areas, "[a]rchivists can, however, more fully envision archival user education to include all aspects of archival intelligence."[32] Clearly, archival intelligence cannot be achieved with a one-hour introductory session or a brief display of cherry-picked items. If STEM undergraduate students are to gain a true understanding of primary source research and useful, transferable skills, archivists must have an understanding of their role in training and guiding novice researchers.

The goal of integrating primary source research into STEM undergraduate curricula is not simply to increase archival intelligence. Students exposed to primary source materials are more likely to understand how secondary source materials are generated, which in turn compels them to think critically about the development of their disciplines.[33] In addition, the skills gained through archival research, such as coping with uncertainty, creative thinking, seeing the big picture, and making connections between concepts, are recognized as important skills for engineering and technology students.

Planning the Course

At the time of this study, the Polytechnic Institute of New York University (NYU-Poly), located in Brooklyn, was a comprehensive school of engineering, applied science, technology, and research.[34] Founded in 1854 as the Brooklyn Collegiate and Polytechnic Institute, it is the nation's second-oldest private engineering school.[35] In 2013, 2,155 undergraduate and 2,735 graduate students were enrolled in the institution.[36] Fifteen bachelor of science degree programs are available to undergraduates; most of these programs are in the fields of engineering and applied science.[37] The urban campus hosts a diverse population, ranging from commuters to international students, with 99 percent receiving financial aid.[38]

The Bern Dibner Library of Science and Technology at NYU-Poly houses the archives of the former university and current engineering school as well as special collections and rare books related to the history of science, technology, and engineering. When I was hired as the archivist and user services librarian in November 2011, the library had been without a trained archivist or special collections librarian for quite some time. While parts of the archives were organized by subject, there were no finding aids. I considered the entire archives to be a "hidden collection."[39] In an effort to promote awareness and use of the archives, I decided not only to focus on processing collections and creating finding aids, but also to actively engage students in the archives and special collections.

While archival instruction is not usually part of the undergraduate STEM curriculum, it is my assertion that learning how to locate and interpret primary source materials enhances the education of STEM students.[40] Besides the general benefits of engaging in archival research, such as strengthening problem-solving skills and developing arguments based on evidentiary materials, STEM majors may encounter the need to research primary source documents in their careers. A need to understand how scientific practices or technologies emerged or to engage in market, company, or patent research could bring professional engineers and scientists to the archives. Furthermore, the current ABET criteria for student outcomes focus on developing engineers and technologists who can make connections, work together on teams to solve problems, communicate effectively, and engage in lifelong learning. These objectives can all be gained through guided archival research and influenced the proposal and design of an archival research course for STEM undergraduates.

Knowing the potential challenges of proposing archival instruction to STEM faculty, my first outreach was to professors in our Technology, Culture, and Society (TCS) Department.[41] While geared toward science and engineering students, this department has one foot in the humanities and therefore seemed like an easier "sell" to integrate archival research into the curriculum for the first time at our university.[42] My initial outreach included information about a specific collection, the Keller Mechanical Engineering Corporation Collection, 1916–1962,[43] which I had recently processed with grant support from the Documentary Heritage Program of the New York State Archives. This collection of an early twentieth-century Brooklyn-based tool and die company appeared to be a good fit within the TCS Department's offerings for STS (science and technology studies) and STEM majors. The primary source materials, including photographs, blueprints, trade publications, and realia, document the evolution of the machines, the proliferation of the machines into diverse markets, and the eventual decline of the company.

After emails with two TCS Department members, I connected with Professor Christopher Leslie, instructor of media, science, and technology studies. After our initial discussions, Professor Leslie decided that rather than merely exposing his students to a show-and-tell version of the archives, he would integrate the collection into his writing-intensive seminar on technology transfer as a semester-long research project.[44] The students, working in small groups, would write collaborative research papers based on their work with the Keller Mechanical Engineering Corporation (KME) Collection in the archives. This research would be grounded in the theme of technology transfer, the subject of Professor Leslie's undergraduate spring 2013 STS seminar (course number STS 3003W). My role in the course was to introduce the students to the archives and archival theory as well as to facilitate access to the collection throughout the semester.

Professor Leslie and I planned the second class of the semester to be a trip to the archives. After this initial introduction, the student groups were expected to schedule appointments with me to use the collection. While the students were required to visit the archives outside of class time, they were also given one free class period during the semester to work on their research. Also, the entire course was structured around the research project; the midterm was a presentation of each group's findings up to that point, which allowed for a class discussion and critique before the final paper. The final grade for the course was based largely on the final research paper.

Early in our planning, we decided to invite Peter Keller, the brother of KME Collection donor, Jane Keller Herzig, to visit during the students' midterm presentations. Mr. Keller was interested in KME (his grandfather, Sidney A. Keller, founded the company; his father, Polytechnic alumnus Richard D. Keller, became head of the sales division in the 1940s) and had completed some research on the company. Our hope was for a symbiotic interaction: Mr. Keller would provide personal insight and background into the company, while the students would provide additional research on a subject important to Mr. Keller. Besides the mutual benefits to both parties, Professor Leslie and I thought that Mr. Keller's presence and feedback would reinforce the study of history as an active, living enterprise rather than merely a classroom exercise.

A Semester in the Archives

When the Polytechnic students signed up for STS 3003W, they knew they were taking a writing-intensive seminar on technology transfer. They did not know that their writing for the class would be based not only on course readings, but on their work with primary sources in the Poly Archives. Professor Leslie and I knew that some students might balk at the idea, but we also knew that today's engineering students are familiar with project-based learning, hands-on research, and team-based projects.[45] Although twenty-two students had registered for the course, by the time I met with the class two weeks into the semester, the group was down to sixteen students. Professor Leslie thought this was a standard shift during the add/drop period, but it is impossible to know for certain whether students dropped the class because they did not want to participate in the semester-long archival research and writing project. It is possible that the students who stayed with the class had more interest in historical research or were inclined to try new types of learning activities than the typical engineering student.

My first meeting with the students began with a visit to the archives for a brief tour of the physical space. We then moved to a classroom with a few boxes of the KME Collection, where I gave an overview of the materials as well as an introduction to using the archives. This included the reasoning behind certain rules, which at first appear draconian to novice archives users (no pens; no coffee), as well as an introduction to basic concepts necessary for access, such as the *finding aid*, and for understanding and interpreting a collection, such as *provenance*. I also went over the private libguide[46] I created for the students, which contained information about using the archives, archival terminology, the KME finding aid, a historical overview of the company written by Peter Keller, suggestions of where to find supporting secondary sources, and my assigned readings, which included Oliver Wendell Holmes's essay, "Archival Arrangement—Five Different Operations at Five Different Levels," and James Fleck's article, "Contingent Knowledge and Technology Development."[47]

After my brief lecture, I let the students look through the selected boxes as I walked around the room. I included this hands-on experience in our initial meeting because I think it is impossible to understand the nature of archives in writing or through lecture alone; the finding aid only begins to make sense once one has a chance to observe the concrete items to which the guide refers. Also, we were asking the students to pick a topic and to form small groups of three to four members very quickly; this exposure to the materials allowed them to identify which aspects of the collection appealed to them.

In the following weeks, the small groups of students made appointments to visit the archives to begin their research. While the groups ranged from the unenthusiastic to the overly ambitious, it was clear that working in the archives was a new experience for all of the students in the class. Initially, Professor Leslie and I planned for my role to be merely a facilitator of access to the materials; however, it quickly became clear that the students needed more support than the typical researcher. An experienced researcher would know how to access a finding aid, identify and select necessary boxes from the collection, and plan sufficient time for visits to the archives. Recognizing the needs of these novice archives users, I took advantage of these meetings to reiterate how to use the finding aid, to explain archival silences, and to nudge students toward helpful databases, such as ProQuest's News and Newspapers. While this extra assistance required more work than a typical research appointment, it was also highly rewarding. Each visit was not merely collecting data for a paper; it was enhancing the students' overall research skills.

Peter Keller's visit halfway through the semester proved to be another valuable learning experience for the students. Some students, worried about insulting Mr. Keller, were nervous about presenting their theories of the demise of the KME Company. The students' anxieties were compounded by the scarcity of records from the company's final years in the collection. These archival silences troubled students in search of definitive answers, but caused them to reassess the way "facts" are gathered and presented. The knowledge that they would meet someone with memories of the company created an acute awareness of the fine line between historical facts, as cited by archival records, and historical conjecture or memory.

Results

At the end of semester, I asked the students to fill out an anonymous, voluntary evaluation of the archival part of the course (see Appendix A). Out of sixteen completed surveys, only one student answered "no" to the question "Did the use of archival material enhance your understanding of research in the field of science and technology?"

Table 1. Responses to Evaluation Question 1

Did the use of archival material enhance your understanding of research in the field of science and technology?

Yes	No	Undefined*
14	1	1

*The student did not answer yes or no, but instead stated: "Using the archival material helped me understand the process of writing papers based on original source material. It's like a web of information except there is an aspect where the pieces of information have gaps connecting to other things" (Respondent 3).

The students' team-based presentations and research papers supported the overwhelmingly positive response to this question. The following examples from one group's presentation demonstrate how the students used photographs and manuals from the KME Collection as a springboard into patent research, which ultimately resulted in a more complex analysis of how products, which begin as detailed engineering designs, are simplified when marketed to targeted consumer audiences.

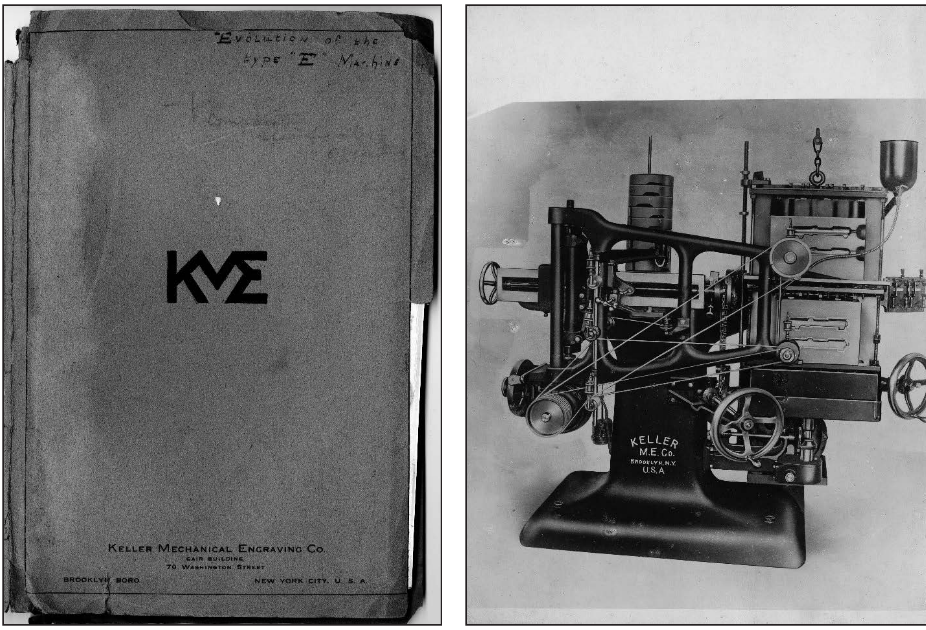

FIGURE 1. Students used materials, like this KME manual and photograph of the type E machine, as the basis for their engineering patent and marketing research. Poly Archives, RG.001, Box 1.

The KME manual, "Evolution of the Type 'E' Machine," caught the attention of this student group, who were looking for a topic within the context of their seminar on technology transfer. The manual includes photographs and descriptions of the machine as it progressed from a prototype to series E1, E2, E3, and E4. Since materials in the collection referenced William Warman as the type E machine inventor, students had enough information to begin patent research into the progression of this machine and Warman's previous inventions. In their presentation, the students explained how Warman's previous work in electricity and turbines led to his creation of the type E machine for engraving and sinking dies. Finally, these students were able to compare the detailed technical patent drawings to the simplified advertisements of the products. By devising their own research project based on evidence from the collection, these students were able to understand not only the evolution of engineering patents, but also how inventions and products are marketed to audiences outside of the science and engineering community. It is clear why these students would answer affirmatively to whether this kind of archival research enhanced their understanding in the field of science and technology.

To produce these successful research projects, the students had to learn how to locate and understand archival materials within a collection. These outcomes, and their responses to the anonymous survey, reveal gains in archival intelligence, as defined by Yakel and Torres. The students seemed to internalize

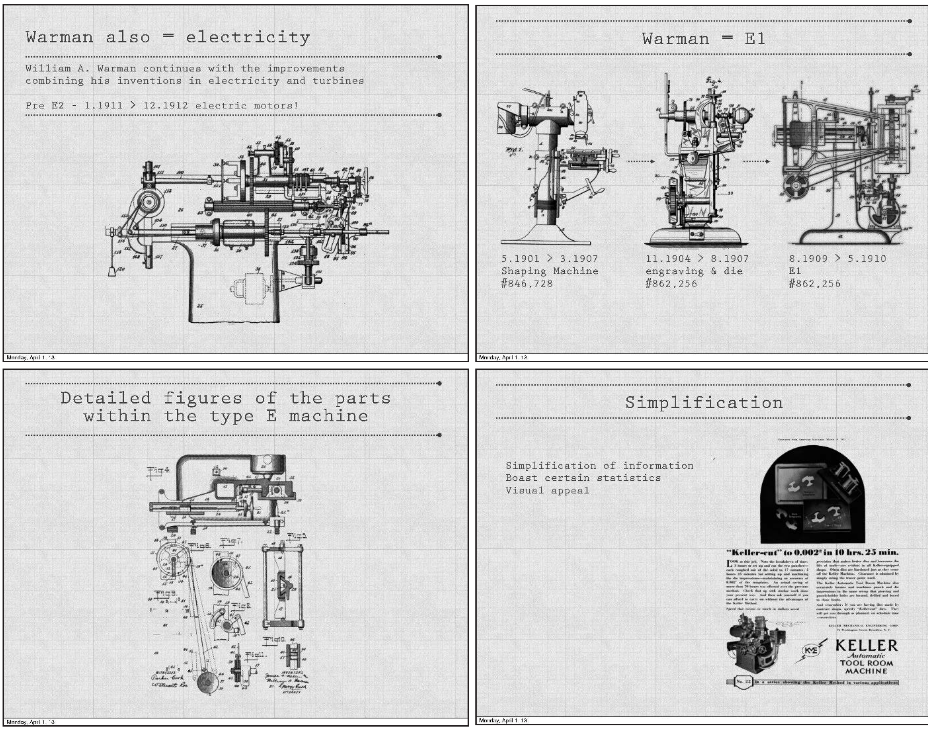

FIGURE 2. This student presentation used archival materials and patent research to demonstrate evolution in engineering concepts and the distinction between technical drawings and marketing to consumers. Reproduced with student permission.

the first principle of archival intelligence—knowledge of archival theories and practices as demonstrated by the ability to locate items, understand arrangement, and gain access to collections—by the end of the semester.

Although limited accessibility to the space frustrated some students, this frustration reveals an understanding of archival access, policies, and practices (i.e., the university archives has different access rules than the university library). For example, when asked "What did you like least about working in the archives?," one student stated, "The hours in which the archives were open. Make the archives more available, especially during weekends" (Respondent 10). To the same question, another student commented, "The temperature is very low. I was frozen when working with archives, but I do understand that temperature should not be high to preserve materials" (Respondent 8).[48] While some archival policies and practices evoked mild frustration, other students were expressly grateful for learning how to access and use archival collections. "Prior to my this [*sic*] visit to the archive, I had never seen one. So, finally I know about archives and how to find something in an archive. Thanks Prof. Leslie" (Respondent 7).

Over the course of the semester, students became more comfortable using a finding aid and locating specific folders or items within the collection. Many expressed that the libguide, which contains the finding aid and supplemental information, was a helpful orientation tool. "Whenever I had to locate something the guide would usually help me out and point me in the right direction" (Respondent 1). Another student found the guide and finding aid "helpful for locating certain files in the archives" (Respondent 6). Although most students used the libguide and found it helpful, some still had difficulty with the finding aid. Many wished for a more granular description than a finding aid typically supplies: "It could have more content description and key words to associate certain boxes and folders" (Respondent 12) and "It was very helpful in helping me find a general area where I would look for more info; however I would have liked to see more specifics as to what is inside each box—maybe a two sentence summary or a suggestion as to where I might find more info" (Respondent 10).

Table 2. Responses to Evaluation Question 4

Did you use the libguide created for your class (http://poly.libguides.com/keller)? If No, why not? If Yes, was it helpful or how could it be improved?

Yes	No	Undefined*
14	1	1

* The student did not answer yes or no, instead stated: "Our group had used the guide very often throughout our research to speed up our information gathering" (Respondent 3).

By the end of the semester, many students were acutely aware of the concept of archival silences. These silences troubled some, but created an enjoyable challenge for others. When asked, "What did you like least about working in the archives?," one student replied, "I thought that archives were like Wikipedia of a company, where I could find everything. But I think in our case the [indecipherable word] research materials were a little disappointing at times" (Respondent 7). The students who perceived the archival collection—complete with archival silences—"like a puzzle" were more likely to develop strategies for finding supplemental information or to redefine their research question, for example: "Even though working with an archives is difficult because you have to decipher a lot of information, I enjoyed the mystery-like work. I reviewed material and then came up with a hypothesis rather than the normal project of defining a thesis and then working off of it" (Respondent 11); and, "Being able to take [*sic*] copies and use the archives firsthand was an interesting experience. I enjoyed the opportunity to piece information together on my own and draw conclusions" (Respondent 9). These two respondents show competency in Yakel and Torres's second principle of archival intelligence: developing strategies to reduce uncertainty and ambiguity when unstructured problems and ill-defined situations are the norm. Respondent 11's strategy for reducing the uncertainty of unstructured problems was to flip his or her typical research style. This student took the time to review the collection before defining a research topic; a more sophisticated and fluid approach than attempting to arrange new information according to preconceived notions. Respondent 9 internalized that in the archives ill-defined situations are the norm. Realizing this, he or she formulated the strategy of piecing information together to understand the collection as a whole.

Finally, these STEM undergraduates developed Yakel and Torres's third facet of archival intelligence, intellective skills, which is defined as the ability to understand representations of documents, activities, and processes. Understanding how various documents fit together provided insight into the general concept of knowledge production. According to one student, "I now know that this is how history gets recorded. Through the use of direct sources interpretations are made" (Respondent 15).

Working with primary source materials and conducting their own research allowed the students to see how historical narratives and secondary sources are formed. For example, Respondent 9 stated, "It was very eye-opening to see how much the historical narratives we use are taken for granted. Understanding how these narratives are pieced together from various sources and conclusions gives insight on thing [*sic*] that may be only part of the truth in a particular context." Similarly, Respondent 2 said that what he or she liked best about working in the archives was "Being able to get a sample of what archival research involves and an appreciation for the finished works we typically reference that included archival research." These responses show that a hands-on experience with primary source materials helped these students to see the bigger picture and to make connections about knowledge production in STEM disciplines.

Beyond gains in archival intelligence, most of the students enjoyed the opportunity to physically handle primary source materials. One student stated that what he or she liked best was "To be able to see and feel the originality of materials that contribute to a research that I am conducting" (Respondent 8). Perhaps most interesting was the attraction of these "digital natives"[49] to materials that were not easily accessible—or available at all—online. One student succinctly stated, "Exclusivity of the information provided. Can't find the info anywhere online" (Respondent 13), while another elaborated, "What makes the whole experience of working in an archives interesting is the feeling that you are looking at stuff that is not so general. Availability of manuscripts, sales, advertisements, made it so easy to understand that was that [*sic*] what industry [was] like back then" (Respondent 7). Understanding this interest in nondigital materials helps to clarify what first seemed like a contradictory reply to what one student liked *best* about working in the archives: "Access to the material not easily available" (Respondent 3).

Alternatively, some students' least favorite part of the course was the limited access to the archives. "The access was restricted, the room itself was not great" (Respondent 5). This quote touches on the other top complaint about the archives: the room itself. Like many archives, the room is designed more for shelving than for comfort. With no dedicated reading room, the small table in the archives is the only place to conduct research. "The space was probably what I liked least. If there were more than 2 people in there at a time it became pretty difficult to work with the archival materials, especially when one was dealing with fragile materials" (Respondent 1).

Overall, the student responses reveal a positive learning experience, an increase in archival intelligence, and a greater understanding of STEM knowledge production over the course of the semester. Responses such as "It was a great learning experience. I'm surprised this has not been incorporated into other class curriculums [*sic*]" (Respondent 4) reveal not only a self-perceived intellectual gain, but a desire for broader implementation of archival research into STEM curricula.

The responses also helped me understand ways in which I could improve the course if I were to do it again. The first change would be to give students the option of selecting a predetermined research topic or to choose topics on their own. While some students enjoyed the freedom of choosing their own topics, others floundered and lost valuable research time by bouncing between too many ideas. Formulating a topic and conducting solid research may take more time than is reasonable to expect most novice archives users to be able to accomplish in one semester. The second change would be to secure a separate room in the library to store the collection and to act as a reading room for the semester. Since the research was limited to one moderately sized collection (11.5 cubic feet; 27 boxes), this could probably be accomplished with sufficient planning. Finally, I wish I had given the students a pre-evaluation of what they knew about archives during our first meeting. While I enjoyed watching these undergraduates become more proficient researchers over the course of the semester, I lack a qualitative comparison.

Conclusion

Successful archival outreach to and instruction of STEM undergraduates can be achieved through proper planning and faculty support. Integrating primary source research into the STEM curriculum involves identifying an appropriate collection, reaching out to faculty members, and collaborating through course development and implementation.

The undergraduate students in this study required more support than the typical researcher. While further studies could show if this is always the case, it would be prudent for archivists planning to incorporate primary source research into STEM curricula to be prepared to teach the students archival and research skills throughout the semester, rather than expecting a preliminary lecture to be sufficient. However, this time commitment has its rewards. After the semester-long archival research project, our undergraduate students achieved improvement in all three areas of archival intelligence and gained practice in valued ABET student outcomes, such as analysis and interpretation of data, the ability to function on multidisciplinary teams, practice with effective oral and written communication, and a greater understanding of science and engineering within global, economic, environmental, and societal contexts. The biggest contributing factor to our success in this project was the acknowledgment, by both the archivist and the professor, that undergraduate STEM students can and should be subjects of archival outreach. It is my hope that the success of this case study will encourage other archivists and STEM faculty to engage students in meaningful primary source research.

Appendix A

Evaluation of Archival Instruction in STS 3003W (Seminar in Science and Technology Studies)

1.) Did the use of archival materials enhance your understanding of research in the field of science and technology?
    If Yes, how?
    If No, why not?
2.) What did you like best about working in the archives?
3.) What did you like least about working in the archives?
4.) Did you use the libguide created for your class (http://poly.libguides.com/keller)?
    If No, why not?
    If Yes, was it helpful or how could it be improved?
5.) If I were to integrate archival work into another course, how could I improve the archival instruction and research portions of the class?

Notes

[1] "President Obama Expands 'Educate to Innovate' Campaign for Excellence in Science, Technology, Engineering, and Mathematics (STEM) Education," January 6, 2010, The White House Press Office, http://www.whitehouse.gov/the-press-office/president-obama-expands-educate-innovate-campaign-excellence-science-technology-eng.

[2] "Core Archival Functions," Society of American Archivists, Guidelines for College and University Archives, http://www2.archivists.org/node/14804.

[3] The "engineering science" model is based on the idea that engineering education begins after at least two years of foundation courses in math and science. Only after this solid basis in theory do students begin to apply scientific principles to technological problems.

[4] Clive Dym, Alice Agogino, Ozgur Eris, Daniel Frey, and Larry Leifer, "Engineering Design Thinking, Teaching, Learning," *Journal of Engineering Education* (January 2005): 103–20; Linda Vanasupa, Jonathan Stolk, and Roberta Herter, "The Four-Domain Development Diagram: A Guide for Holistic Design of Effective Learning Experiences for the Twenty-first Century Engineer," *Journal of Engineering Education* (January 2009): 67–81.

[5] Peter Carini, "Archivists as Educators: Integrating Primary Sources into the Curriculum," *Journal of Archival Organization* 7, nos. 1–2 (2009): 41–50, doi:10.1080/15332740902892619; Doris J. Malkmus, "Primary Source Research and the Undergraduate: A Transforming Landscape," *Journal of Archival Organization* 6, nos. 1–2 (2008): 47–70, doi:10.1080/15332740802235125.

[6] Greg Johnson, "Introducing Undergraduate Students to Archives and Special Collections," *College and Undergraduate Libraries* 13, no. 2 (2006): 91–100, doi:10.1300/J106v13n02_07; Shan Sutton and Lorrie Knight, "Beyond the Reading Room: Integrating Primary and Secondary Sources in the Library Classroom," *The Journal of Academic Librarianship* 32, no. 3 (May 2006): 320–25, doi:10.1016/j.acalib.2006.03.001; Magia G. Krause, "'It Makes History Alive for Them': The Role of Archivists and Special Collections Librarians in Instructing Undergraduates," *The Journal of Academic Librarianship* 36 (September 2010): 401–11, doi:10.1016/j.acalib.2010.06.004; Ann Schmiesing and Deborah Hollis, "The Role of Special Collections Departments in Humanities Undergraduate and Graduate Teaching: A Case Study," *Portal: Libraries and the Academy* 2, no. 3 (2002): 465–80, doi:10.1353/pla.2002.0065; Carini, "Archivists as Educators"; Malkmus, "Primary Source Research and the Undergraduate."

[7] Krause, "It Makes History Alive for Them," 251.

[8] Krause, "It Makes History Alive for Them," 251.

[9] Carini, "Archivist as Educators," 45.

[10] Dym, "Engineering Design Thinking, Teaching, and Learning," 103.

[11] Dym, "Engineering Design Thinking, Teaching, and Learning," 103.

[12] Lyle Feisel and Albert Rosa, "The Role of the Laboratory in Undergraduate Engineering Education," *Journal of Engineering Education* (January 2005): 121–30.

[13] Feisel and Rosa, "The Role of the Laboratory in Undergraduate Engineering Education," 121; Dym, "Engineering Design Thinking, Teaching, and Learning," 103.

[14] Dym, "Engineering Design Thinking, Teaching, and Learning," 104; Feisel and Rosa, "The Role of the Laboratory in Undergraduate Engineering Education,"127.

[15] Meier, Williams, and Humphreys, "Refocusing Our Efforts: Assessing Non-Technical Competency Gaps," 377.

[16] Meier, Williams, and Humphreys, "Refocusing Our Efforts: Assessing Non-Technical Competency Gaps," 383.

[17] "ABET General Criterion 3: Student Outcomes," Criteria for Accrediting Engineering Programs 2015–2016, http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-computing-programs-2015-2016/#outcomes.

[18] Vanasupa, Stolk, and Herter, "The Four-Domain Development Diagram: A Guide for Holistic Design of Effective Learning Experiences for the Twenty-first Century Engineer," 67.

[19] Vanasupa, Stolk, and Herter, "The Four-Domain Development Diagram: A Guide for Holistic Design of Effective Learning Experiences for the Twenty-first Century Engineer," 76.

[20] Vanasupa, Stolk, and Herter, "The Four-Domain Development Diagram: A Guide for Holistic Design of Effective Learning Experiences for the Twenty-first Century Engineer," 76.

[21] Sutton and Knight, "Beyond the Reading Room," 321.

[22] Cory L. Nimer and J. Gordon Daines III, "Teaching Undergraduates to Think Archivally," *Journal of Archival Organization* 10, no. 1 (2012): 4, doi:10.1080/15332748.2012.680418.

[23] Elizabeth Yakel and Deborah A. Torres, "AI: Archival Intelligence and User Expertise," *The American Archivist* 66 (Spring/Summer 2003): 51–78.

[24] Nimer and Daines, "Teaching Undergraduates to Think Archivally," 5; Carini, "Archivists as Educators," 44.

[25] Yakel and Torres, "AI: Archival Intelligence and User Expertise," 51.

[26] Yakel and Torres, "AI: Archival Intelligence and User Expertise," 52.

[27] Yakel and Torres, "AI: Archival Intelligence and User Expertise," 67.

[28] Yakel and Torres, "AI: Archival Intelligence and User Expertise," 69.

[29] See footnote in Walter R. Reitman, *Cognition and Thought* (New York: Wiley, 1965), 141, on Yakel and Torres, "AI: Archival Intelligence and User Expertise," 69.

[30] Yakel and Torres, "AI: Archival Intelligence and User Expertise," 73.

[31] Yakel and Torres, "AI: Archival Intelligence and User Expertise," 75.

[32] Yakel and Torres, "AI: Archival Intelligence and User Expertise," 78.

[33] Sutton and Knight, "Beyond the Reading Room," 322.

[34] Following the completion of a merger with New York University (NYU) on January 1, 2014, Polytechnic became a school within NYU. It is now the NYU Polytechnic School of Engineering.

[35] NYU Polytechnic School of Engineering, "About," http://engineering.nyu.edu/about.

[36] NYU Poly, "Polytechnic Institute of New York University Quick Facts," http://engineering.nyu.edu/files/ftp/files/NYU-Poly%20Quick%20Facts%20June%20%202013.pdf.

[37] Bachelor of science programs include Applied Physics, Biomolecular Science, Business and Technology Management, Chemical and Biomolecular Engineering, Civil Engineering, Computer Engineering, Computer Science, Construction Management, Electrical Engineering, Integrated Digital Media, Mathematics, Mechanical Engineering, Physics and Mathematics, Science and Technology Studies, and Sustainable Urban Environments.

[38] Ranked number 2 by Matthew Lynch, "30 Best U.S. Non-HBCU Schools for Minorities," with 52 percent minority students and 99 percent receiving financial aid, Diverse Issues in Education, http://diverseeducation.com/article/53530/#.

[39] OCLC defines *hidden collections* as "those special collections and archives that are undescribed or underdescribed, and therefore undiscoverable," Survey of Special Collections and Archives in the U.S. and Canada, OCLC Research, http://oclc.org/research/activities/hiddencollections.html.

[40] Re-evaluating the way we teach all levels of students in all disciplines is a worthy endeavor. See Emily Hanford, "Rethinking the Way College Students Are Taught," American Radioworks, http://americanradioworks.publicradio.org/features/tomorrows-college/lectures/rethinking-teaching.html.

[41] NYU Polytechnic School of Engineering, "Technology, Culture, and Society Department," http://engineering.nyu.edu/academics/departments/tcs.

[42] I have explored outreach to "hard" science and engineering areas at the university, such as physics and civil engineering; however, I proposed these projects in different ways to meet the needs of different populations. For example, in physics, my outreach was to the Society of Undergraduate Physicists (SOUP) rather than to the faculty for integration into a fundamental physics class. See Lindsay Anderberg, "SOUP and Symmetry: Physics Majors Explore an Archival Collection," *Metropolitan Archivist* 20, no. 1 (2014): 10–11.

[43] "Keller Mechanical Engineering Corporation Collection RG.001," Poly Archives and Special Collections, http://dlib.nyu.edu/findingaids/html/poly/keller/.

[44] Instructive articles during the planning of the course included the previously cited articles, as well as Trevor James Bond and Todd Butler, "A Dialog on Teaching an Undergraduate Seminar in Special Collections," *Library Review* 58, no. 4 (2009): 310–16, doi:10.1108/00242530910952855.

[45] PBL is a pedagogical method in areas outside of engineering as well. It is most often adopted by engineering design courses, as it is thought that a hands-on approach to design is a better learning experience than merely digesting theory. See Dym, "Engineering Design Thinking, Teaching, and Learning," 104.

[46] "Keller Collection and STS Seminar," NYU Libraries, http://poly.libguides.com/keller.

[47] James Fleck, "Contingent Knowledge and Technology Development," *Technology Analysis and Strategic Management* 9 (1997): 383–98; and Oliver W. Holmes, "Archival Arrangement—Five Different Operations at Five Different Levels," *The American Archivist* 27 (January 1964): 21–41.

[48] During the 2013 spring semester, the average temperature in the archives was 65.4 degree F, although it spiked to 77 degrees in May and was as low as 60.7 degrees in January. Pleading the case for climate control is an ongoing challenge.

[49] As defined by Marc Prensky in 2001, *digital natives* are "Today's students—K through college—[who] represent the first generations to grow up with this new technology. They have spent their entire lives surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all the other toys and tools of the digital age, "Digital Natives, Digital Immigrants," *On the Horizon* 9 (October 2001), http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf.

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