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FRANCES ARNOLD AND THE MATHEMATICAL EDUCATION OF GIRLS IN HER TIME

Summary: This work explores the life and career of Frances Arnold, a mathematics teacher at the Brearley School from 1898 to 1930. Brearley, a girls-only school established in New York at the end of the 19th c., set out to offer a rigorous education for girls, equal to that of boys in similar institutions. Frances Arnold's connection to Brearley began as a student, and later, she returned to the school as a teacher and headmistress. Throughout her life, Arnold remained a dedicated advocate for women's rights, and this commitment was evident during and after her tenure at Brearley. The goal of this work is to examine Arnold's contributions to mathematics education at Brearley, focusing not only on her merits as a teacher but also on her lasting impact on the educational principles of girls' mathematics education.

Keywords: Brearley School, girls-only school, female education, Frances Arnold, female mathematics education, mathematics education, Progressive Era

Introduction

This study focuses on Frances Arnold, a mathematics teacher at the girls-only Brearley School in New York City. Frances Arnold taught at Brearley from 1898 through the 1930s. Her career spanned a period when opportunities for women in education were significantly shaped by the evolving social and economic landscape in the United States. Arnold's approach to teaching, her innovative methods, and her impact on the educational community at Brearley are of particular interest, as they provide valuable insight into the evolution of mathematics education during this era. By examining her work, the goal is to understand better

the challenges and achievements faced by women educators in the late 19th and early 20th c., as well as the influence of progressive educational reforms on the teaching of mathematics at the time.

An intriguing point: portrait of an individual educator

One might argue that focusing on the work of a single educator could seem narrow or unrepresentative of broader historical trends. However, the aim of this research is not only to examine the contributions of one individual teacher but also to gain insights into educational practices, philosophies, and the impact of teaching on students – specifically in the context of girls' mathematics education. At the same time, care must be taken not to generalize and not to use the example of one teacher as a reflection of broader educational practices. However, this micro-historical approach offers a valuable perspective by revealing how broader educational reforms and societal changes are experienced at the ground level. By examining the methods and beliefs of a single educator, this study seeks to deepen our understanding of how specific teaching practices may have influenced students and, in turn, contributed to wider shifts in mathematics education. This consideration highlights the importance of individual educators in shaping mathematics education and underscores the impact of personal teaching methods and philosophies on the field.

By focusing on one educator, we can also appreciate the unique challenges they faced, the innovations they brought to their classrooms, and the personal qualities that made their teaching memorable. This approach can humanize the history of education, offering a more nuanced understanding of how teaching and learning have evolved over time, and highlighting how practices in one educational institution may have differed from those in another.

Lastly, researching a specific educator allows one to draw meaningful parallels. This work also incorporates a general review of contemporary mathematics educators who influenced girls' education, including those working or studying at institutions other than where Frances Arnold worked, as well as influential educators of the time who had an impact on girls' mathematics education.

Research questions

This study was guided by the following themes:

- A thorough examination of the regional context and time period, considering changes in the United States and region-specific factors. Particular attention is given to the changing landscape of mathematics education for girls during this time.
- An overview of Brearley's approach to education, and particularly mathematics education, as compared with other girls-only schools.

- The specific achievements of Frances Arnold as a mathematics educator.
- The mathematics teacher's role as well as their personal views on preparing students for higher education vs. immediate employment.

Methodology

This study focuses on a comprehensive analysis of primary and secondary sources related to Frances Arnold's education and professional activities. Special attention was given to official documents from the institutions where she received her education, specifically the Brearley School and Bryn Mawr College. To explore her professional contributions to mathematics education, relevant periodicals addressing education and gender issues were also examined, with attention to the socio-political complexities and gender dynamics of the time.

A key component of this study was the examination of personal letters and manuscripts written by Frances Arnold, as well as letters and commemorations by her peers and students. These sources provided valuable insights into her experiences and impact within the field, and allowed for a closer assessment of her impact on students. Additionally, the research involved comparing Arnold's career with those of other contemporary female educators and administrators. To further contextualize her work, the analysis incorporated perspectives from other historians, enabling a deeper understanding of the social and political factors that shaped the educational landscape during her time.

Chronicles of time and place

To understand why this work concentrates on this particular educator, at a specific school, during this particular time, warrants a detailed examination of each component. Therefore, the years when Frances Arnold was active in her teaching career, from 1898 to 1930, which align with the period in the United States known as the Progressive Era, require special attention.

During the Progressive Era, a social awakening and a widespread desire for change began to take shape across various institutions and organizations. Key reforms during this period focused on issues such as family welfare, education, women's suffrage, the strengthening of local government, and the pursuit of better working conditions and rights[1]. As a result, the Progressive Era was characterized by a wave of social reforms addressing a wide array of issues, from education to labor, living conditions, and political rights. The era was shaped by an awakening social conscience, which viewed improved education as the solution

[1] Y. Shvartsberg, *Toward a History of Mathematics Education for Young Women: 1890–1920*, [in:] *Advances in the History of Mathematics Education*, ed. by A. Karp, Springer, Cham 2022, p. 195–216.

to poverty[2]. While social changes certainly influenced education, this relationship was reciprocal. Educational reforms of the 19th c. also contributed to the rise of social consciousness. Historians suggest that the demand for greater social and legal rights for women would not have gained momentum without the increase in female education and school enrollment that followed the Revolutionary War[3].

Furthermore, the Progressive Era represented a significant peak in women's participation in collegiate life, a level that would not be matched again until the 1980s. By 1920, women made up 47 percent of all college students. Meanwhile, in high schools, the enrollment of girls surpassed their proportion in the general population. The *Biennial Survey of Education in the United States, 1916–18*, presented the following numbers in relation to the overall high school enrollment in the United States:

> Of the 1,645,171 secondary students, 704,856 are boys and 940,315 are girls. Over one-half of the total high-school enrollment, or 57.2 per cent, consists of girls. In fact, the number of girl students has been larger than the number of boys each year […]. There has been, however, little change since 1890 in the proportion of girls and boys. In 1890, girls constituted 57.7 per cent of the students; in 1900, the corresponding per cent had increased to 58.3; in 1910, it had decreased to 56.4; in 1916, it decreased still further to 54.6, but in 1918, it had risen to 57.2. The increase in the proportion of girls in 1918 was probably due to war conditions – the boys going to work, the girls continuing in high school.[4]

Overall, it can be concluded that, with little fluctuation, girls constituted the majority of the population in high schools. However, although the number of women grew in high schools and undergraduate institutions, the picture was less encouraging at the postgraduate level. For example, the number of female physicians dropped from 6% in 1910 to 4% in the 1930s. At the same time, women represented more than two-thirds of librarians, nurses, and social workers by the 1930s, while men still held managerial and leadership roles. The majority of teachers were women as well; however, only one-third of the nation's superintendents were women[5].

In general, this period saw significant growth in women's participation in the labor force, with the proportion of women in the workforce increasing by nearly

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[2] L.A. Cremin, *The Transformation of the School: Progressivism in American Education, 1876–1957*, Alfred A. Knopf, New York 1962.

[3] J.L. Rury, *Education and Women's Work: Female Schooling and the Division of Labor in Urban America, 1870–1930*, State University of New York Press, Albany 1991.

[4] U.S. Department of the Interior, Bureau of Education, *Biennial Survey of Education 1916–18*, vol. 4, Government Printing Office, Washington, DC 1921 (Bulletin, 1919, no. 91), p. 152.

[5] L. Eisenmann, *Historical Dictionary of Women's Education in the United States*, Greenwood Press, Westport, CT 1998, p. 245.

33 percent nationally[6]. However, the careers that became popular among women were often distinct from those pursued by men, with commercial jobs in urban areas becoming a central focus. Commercial courses were available to both boys and girls, but these programs were primarily seen as suited for females. A survey from 1917, completed by 66 high school principals, demonstrates that two-thirds of the respondents agreed that commercial training for boys and girls should differ. Furthermore, it highlighted that, regardless of initial career positions, boys advanced into administrative roles, while women typically remained in secretarial and clerical positions until marriage[7]. Despite these limitations, girls were still drawn to commercial jobs, as working hours were relatively short, and salaries were comparatively high. Data from 1913 supports the idea that the increase of men and women in these occupations was not proportional between the genders: 'Of 66,617 boys and 65,191 girls from 14 to 16 years tabulated by the permanent Census Board, there were as stenographers 586 boys and 3,244 girls; as bookkeepers 824 boys and 1,364 girls, i.e., preponderance of girls in clerical positions'[8]. These numbers support the notion that certain professions were popular among girls, and those professions attracted a great portion of them. Hence, there was a need for curricula that would provide quick and streamlined access to these opportunities, which led to a growing movement advocating for students to elect certain classes they deemed necessary for their future careers and to differentiate requirements for graduation based on the foreseen vocation.

The introduction of the elective principle and differentiated curriculum in high schools allowed educators and policymakers to reconsider the goals of classes such as Latin, history, algebra, and geometry in relation to students' future careers. Formal instruction in arithmetic, which could take up a significant portion of the school day, was often blamed for students falling behind or repeating grades. Reformers called for a more functional curriculum – one that would better prepare students for their future careers. Although subjects like Latin and history were also criticized for lacking practical value, mathematics stood out as a primary concern[9].

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[6] J. Rury, *Education and Women's Work: Female Schooling and the Division of Labor in Urban America, 1870–1930*, p. 57.

[7] J.L. Rury, *Vocationalism for Home and Work: Women's Education in the United States, 1880–1930*, "History of Education Quarterly" 1984, vol. 24, no. 1, p. 21–44.

[8] Bureau of Municipal Research, *A Digest of the New York School Inquiry: Submitted to the New York Board of Education, July 17, 1913*, Bureau of Municipal Research, New York 1913, p. 41.

[9] J. Kilpatrick, *The Social Efficiency Movement in the United States and Its Effects on School Mathematics*, [in:] "*Dig Where You Stand". Proceedings of the Conference Ongoing Research in the History of Mathematics Education, June 20–24, 2009, Garðabær, Iceland*, ed. by K. Bjarnadottir, F. Furinghetti, G. Schubring, University of Iceland – School of Education, Reykjavík 2009, p. 113–122.

Consequently, this shift marked a significant moment in the history of education, as it allowed students to avoid mathematics courses such as algebra and geometry, which used to be part of the required high school curricula[10]. Therefore, mathematics classes had to compete with courses that might be considered more useful at the time, and for female students these included bookkeeping and stenography.

Increased demand for commercial education created changes in the training of mathematics teachers as well. Evidence of this is seen in the annual reports by the chair of the Hunter Normal College mathematics department for the years 1915 through 1923. Hunter Normal College was one of the major teacher preparation schools in the New York City area. Most public high schools in New York City employed teachers from Hunter Normal College during the period under review. Professor Emma Requa, chair of the Hunter Normal College mathematics department in 1916, described the condition of the department for the year of 1915, stating the following: 'the Association of Teachers of Mathematics in the Middle States and Maryland – its New York Section – and the Mathematics Section of the New York High School Teachers Association have given their almost undivided attention to the teaching of Commercial Algebra and Commercial Arithmetic in the high schools'[11]. It is also notable that Dr. Requa stated in 1923 regarding commercial courses: 'The recognition of the value of commercial training is universal. Almost every high school in this country furnishes [some] commercial course, while others are purely commercial'[12].

[10] According to the *Third annual report of the City Superintendent of Schools to the Board of Education for the year ending July 31, 1901*, high school curricula were divided into the Classical, One Foreign Language, Two Foreign Languages, and Commercial tracks. Mathematics was required in the first two years, with algebra in the first year and geometry in the second year. Afterward, it continued for the Classical and Foreign Language tracks with algebra, geometry, and trigonometry in the third and fourth years. For the Commercial track, mathematics was required only in the first two years, covering algebra and geometry (Department of Education, City of New York, *Third annual report of the City Superintendent of Schools to the Board of Education for the year ending July 31, 1901*, Department of Education, City of New York, New York 1901, p. 64-69). By 1916, while traditional high schools offered nonvocational courses, many also provided elective commercial subjects and specialized courses for girls in domestic science and art. Students who chose these paths could graduate with only commercial arithmetic as their mathematics requirement, bypassing algebra and geometry (*High schools of New York City: A hand-book of procedure and personnel*, ed. by C.F. Walker, R.C. Jeffords, High School Teachers' Association of New York City, New York 1921, p. 30).

[11] Hunter College of the City of New York, Hunter College Libraries, Archives & Special Collections, Hunter College High School Collection, Series 1 – Administration, Box 1, Folder 2 (Annual Reports), *Hunter College High School Annual Report*, 1916, p. 2.

[12] Ibidem, p.3.

Mathematics as electives

As educational programs of the time began to develop different tracks to accommodate students for different vocations, many questioned whether the goal of mathematics education should be tied exclusively to efficiency or whether other considerations, such as fostering intellectual curiosity or equality of opportunity, should also play a role. Therefore, the term 'belief' is used in this study to underscore the perceived usefulness of mathematics, particularly in relation to gender differences and mathematics achievement: while many supported the elective system, there was also significant opposition. Furthermore, while there was no uniform agreement among educators regarding the elective principle, elective curricula and the changes described above were felt differently in public and private education. In particular, given that the expansion of access to free education was critically connected to this period, it became generally accepted during this time that young people benefited from education, and that access to free public education for all citizens was a necessity. This led to the education of diverse groups from different social and economic backgrounds. Meanwhile, private schools, which required tuition, primarily served students aiming to pursue higher education[13]. As a result, their curricula were designed to prepare students for this academic path. These varying perspectives reveal the complexity of educational debates during this time and highlight the ongoing tension between different philosophies of education, particularly regarding the accessibility and value of mathematics education for all students. This also underscores the need to review the specific school where Frances Arnold spent her entire teaching career: Brearley.

Brearley School

Brearley, a girls-only school, was founded in 1884 by Samuel Brearley with the backing of Caroline Choate, a leading advocate for social and educational reforms for girls in New York City. When Choate discovered that a request to admit women to Columbia University had been rejected on the grounds that women were not adequately prepared for university-level studies, she reached out to Samuel Brearley for assistance in founding a school that would meet university standards and prepare girls for admission to undergraduate programs[14]. According to Joan Challinor, a Brearley alumna and former chairperson of the National Commission

[13] P.E. Sargent, *A Handbook of American Private Schools*, Sargent Handbooks, Boston, MA 1918, p.15.

[14] M.B. Spectre, *Guide to Mabel Choate Papers Regarding Naumkeag, 1855–1958*, NK.MS. Coll.1, The Trustees of Reservations, Archives & Research Center, Sharon, MA, February 2015 (Last updated: October 2019), p. 3, https://thetrustees.access.preservica.com/wp-content/uploads/sites/72/2020/09/NKMSCOLL1_findingaid.pdf [accessed 1.01.2026].

on Libraries and Information Science, Samuel Brearley borrowed money from a Harvard classmate, who was also the great-nephew of Napoleon Bonaparte, to establish the school. Challinor also confirms that the goal of the school to offer young women an education on par with that of boys in similar institutions was indeed realized. She recalls how, even as a student, she recognized the value of education and how the school fostered excitement for learning. Challinor attributes this to the high quality of the teachers, who were not only faithful to their profession but also committed to their students' growth. Though Challinor did not consider herself a natural scholar, she acknowledges that the education Brearley provided laid the foundation for a future full of opportunities.

Despite the shifts in educational practices and the adjustment of curriculum offered in high schools to meet the demands of future vocations, Brearley maintained a traditional curriculum and teaching methods, setting it apart from many other schools. To be admitted to the Brearley School, students were required to pass an examination in English reading and writing, as well as arithmetic, to demonstrate readiness for their grade level. When it comes to the mathematics curriculum offered at Brearley, the 1897–1898 yearbook shows that the mathematics curriculum was designed to prepare students for the entrance exams of prestigious universities like Radcliffe (Harvard), Bryn Mawr, and Barnard. Brearley graduates also gained admission to Smith, Vassar, and Wellesley, with their acceptance often secured by Brearley's certification. This commitment to a college-preparatory curriculum was reinforced by meeting notes from 3 December 1913, which discussed the importance of offering a course of study that ensured the same high standard of preparation for all students, whether they were planning to attend college or not. The consensus was that the curriculum should be comprehensive enough that students who pursued higher education would require no additional preparation[15]. The absence of modifications to the mathematics curriculum during the Progressive Era, as confirmed by a letter written by Annie Ware Winsor Allen, an educator and founder of the Roger Ascham School in White Plains, New York, who taught at the Brearley School from 1889 to 1900:

> These rules [curriculum requirements] remained unchanged over the course of 35 years and through changes of management. […] So the whole Progressive Education wave swept by Brearley without touching it. Fortunately, enough; for its own plan had been ahead of times and was fundamentally sound for any era. So, though Brearley became "old-fashioned", it did not become stagnant.[16]

[15] Schlesinger Library on the History of Women in America, Radcliffe Institute for Advanced Study, Harvard University [SL], Brearley School Archive (1905–1906, 1910–1912) [BSA], Box 1, Folder 2, *Curriculum/College Entrance, J.G. Croswell*.

[16] SL, Brearley School Correspondence, 1932–1950, Series II, Papers of Annie Ware Winsor Allen, 1818–1993, MC 322, 165, 15.01.1950.

Thus, as Mrs. Allen emphasizes, Brearley maintained a consistent, demanding academic program. This approach suggests that mathematics coursework at Brearley was designed to be comprehensive, rigorous, and mandatory for all students, not just those aiming for college.

At the same time, as highlighted in a letter from Martha Carey Thomas, president of Bryn Mawr College, there was a concern that private schools, particularly those for girls in large cities, were struggling to maintain high academic standards due to external pressures from parents and urban changes. Thomas noted that many schools could only maintain rigid standards by adhering to college preparation, a strategy that helped Brearley to keep its inflexible curriculum, where mathematics was not moved to the list of elective courses. This letter further confirms that Brearley's independence from broader educational reforms not only allowed it to resist the trend of lowering academic standards but also set this school apart, since this approach was not universal across all private schools[17]. This overview of the school sets the stage for a closer look at one particular mathematics educator, Frances Arnold.

Frances Arnold

Frances Arnold was deeply embedded in Brearley during the Progressive Era, having started there as a student and graduated in 1893. After receiving her undergraduate degree at Bryn Mawr College, she returned to Brearley as a mathematics teacher and served as the acting Head from 1928 to 1930. Arnold's position as a mathematics educator was especially notable in the context of the transformative period discussed earlier, a time when educational reform was reshaping curricula and teaching methods.

According to Arnold's memories as a student, the Brearley School represented a pioneering experiment in girls' education, particularly for its promise to provide a rigorous, college-preparatory curriculum: 'I remember very definitely the knowledge that I was going to a new school and that this school was a school with an "Idea"'[18]. Arnold emphasized the visionary work Brearley had undertaken, creating a school for girls that offered an education rigorous enough to prepare them for the Harvard Examinations – a standard that very few girls' schools of the time could claim to meet. This innovative approach to educating girls was, in Arnold's view, a daring departure from traditional norms, as she noted that Brearley's method was not only groundbreaking but financially daring: 'A school for girls, with a curriculum that would fit them to take the Harvard Examination was, I fancy, a serious experiment financially'[19].

[17] SL, BSA, Box 1, Folder 2, *Curriculum/College Entrance, J.G. Croswell*.

[18] Brearley School Archives, New York City [BSA-NYC], Record Group: Faculty, Administration, Staff, Box 6, Folder: Arnold, Frances (1898–1930).

[19] Ibidem.

Her firm commitment to both mathematics education and the advancement of women in academia left a lasting impact on those who had the privilege to be her students. One of her former students, Phyllis Goodhart Gordan, who became a leading scholar of the Renaissance, recalled Arnold's ability to make mathematics come alive: 'I remember absolutely nothing about Algebra except Miss Arnold's complete assurance that we could master it; her approach to arithmetic gave numbers so much personality and so many intricate and memorable patterns that they have stayed with me for life'[20]. This personal connection to Arnold's teaching illustrates her skill in making mathematics both engaging and accessible, fostering confidence in her students.

Research on teaching effectiveness supports the view that confidence correlates positively with achievement in mathematics. However, when confidence is researched in the context of gender differences in mathematics, women tend to be less confident than men, and women tend to take less advanced classes than men when elective curricula are a possibility[21]. This idea is echoed in Hansot and Tyack[22], who analyze the institutional history of high schools in the United States through the lens of gender, revealing that while some officials supported differentiated treatment based on gender, few gender-specific policies were actually implemented, particularly in the curriculum. Moreover, they found that in areas such as school admissions, grade promotions, required curriculum, and awards, there was little distinction between boys and girls. However, the authors acknowledge a 'hidden curriculum of sex-stereotyping' that was present in textbooks and classroom practices, as they cite studies of classroom dynamics with examples how teachers and counselors treated boys and girls differently, further perpetuating gender stereotypes. An example of how curricula were reduced to work-related applications through a gender-specific framework during the Progressive Era can be seen in a complaint made by M.V. O'Shea, a professor of education at the University of Wisconsin, in 1912 regarding the mathematics requirements for girls in a text for teachers:

> [N]ot more than one girl in a hundred thousand in the public schools will need algebra for engineering or mechanics. The majority of boys, perhaps, will have need for algebra as a tool; and people go on requiring of the girl what will possibly be of service to the boy, but what is practically certain not to be of value to herself.[23]

[20] BSA-NYC, Record Group: Faculty, Administration, Staff, Box 6, Folder: Arnold, Frances (1898–1930), *Frances Arnold: Commemorate Brearley 125* [letter], 2010.

[21] D.B. McLeod, *Research on Affect in Mathematics Education: A Reconceptualization*, [in:] *Handbook of Research on Mathematics Teaching and Learning: A Project of the National Council of Teachers of Mathematics*, ed. by D.A. Grouws, Macmillan Publishing Co., Inc., New York 1992, p. 575–596.

[22] E. Hansot, D. Tyack, *Gender in American Public Schools: Thinking Institutionally*, "Signs" 1988, vol. 13, no. 4, p. 741–760.

[23] K. Graves, *Girls' Schooling During the Progressive Era: From Female Scholar to Domesticated Citizen*, Garland Publishing, New York, NY / London, UK 1998, p. 216.

Research supports the idea that consistent teacher behavior over time impacts students' self-confidence, motivation, and academic success, with supportive teacher-student relationships being particularly influential in shaping students' attitudes toward subjects like mathematics. Studies have found that students are more confident in environments where teachers are perceived as supportive, which correlates with greater success in learning[24].

Recounts written by the students and colleagues of Frances Arnold highlight her ability to cultivate confidence in her students and her belief in their intellectual potential. Furthermore, they offer a nuanced portrait of a mathematics educator in the late 19th and early 20th c. who reinforced the idea that women were just as capable as men in mastering complex subjects like mathematics. Evidence of this is reflected in her writings about the Women's Rights Movement in the 1970s, where Arnold gave the following advice: 'Women who want equal pay for equal work are foolish! Do that… Why should a woman do the same as a man, when she probably could do something better if she put her mind to it?'[25].

This was not the first movement for women's rights on which Arnold voiced her opinion. From a commemorative letter in the Brearley School Archives: 'Arnold was devoted to women's suffrage but couldn't bring herself "to do all those violent things… kicking and screaming as the men dragged her out". Instead, she relied on reason. She enjoyed a good argument – wanting people not to agree, but to care. To the end, she never hesitated to state her convictions on all subjects, and she always endeavored to give preference to women in all professional fields'[26].

Arnold concluded her teaching career at the school in 1930 when she was 55 years old. In recognition of her exceptional contributions as a mathematics educator, the school established the Frances Arnold Mathematics Prize in 1962, which remains active to this day and is given to a member of the senior class. The award is dedicated to Arnold's, described as 'a woman of wit, enthusiasm, and strong opinions', as well as to her lasting impact on Brearley. Arnold's belief in the potential of women to achieve their fullest capabilities is reflected in the commemorative letter, where it is noted that she saw Brearley as a place where female students are intellectually challenged and able to realize their full potential[27].

As noted in the *Bryn Mawr Bulletin*'s tribute written in her honor, 'To the end, she never hesitated to state her convictions on all subjects, and she consistently

[24] M.L. Mata, V. Monteiro, F. Peixoto, *Attitudes Towards Mathematics: Effects of Individual, Motivational, and Social Support Factors*, "Child Development Research" 2012, vol. 2012, no. 1, p. 1–10.

[25] V.R. Colby, J.B. Atkinson, *Footprints of the Past: Images of Cornish, New Hampshire and the Cornish Colony*, New Hampshire Historical Society, Concord, NH 1996, p. 460.

[26] BSA-NYC, Record Group: Faculty, Administration, Staff, Box 6, Folder: Arnold, Frances (1898–1930), *Frances Arnold: Commemorate Brearley 125* [letter], 2010.

[27] Ibidem.

endeavored to give preference to women in all professional fields'[28]. To summarize Frances Arnold's tenure at Brearley, her dedication to teaching is best captured through the words of Margaret Scott, an English and German language teacher and colleague of Arnold. In 1930, Scott wrote in the *Brearley Bulletin*, in the article *Miss Arnold Retires*: 'Frances Arnold came to Brearley a little girl in Class One; she is leaving a headmistress […] In all the years between – and she has been away only five years since she came as a pupil, at Bryn Mawr, abroad, and in a factory managing a force of women workers during the war – she has made the Brearley a better, a pleasanter place to live in'[29].

Frances Arnold's impact on Brearley is evident in the memories shared in her honor, which reflect her unwavering dedication and her innovative approach to teaching mathematics. She instilled confidence in her students, encouraging them to believe in their ability to succeed rather than fostering doubt. As was mentioned earlier, an environment where students perceive their teacher as supportive fosters a sense of control and confidence, which leads to better learning outcomes. Arnold's approach was visionary, particularly considering the societal shifts during the Progressive Era and the increasing emphasis on providing efficient mathematics education for girls.

Comparing Arnold's methods and influence with those of her contemporaries offers valuable insight into the educational philosophies and practices that shaped the landscape of women's education in the early 20th c. Therefore, it is important to draw parallels and review contemporaries' views into educational philosophies.

Parallels and conclusion

The introduction of an elective curriculum, which allowed students to opt out of certain subjects, produced mixed reactions. Widespread discussions took place in various channels, from conferences to newspaper articles. On 12 June 1915, Henrietta Rodman, a New York City high school teacher, published an article in the "New York Tribune" in which she quoted Maud Thompson, secretary of the Socialist Committee on Education, who said:

> It is not the school's business to fit a child to meet an employer's demands, but the school should teach the main facts and processes of industry, so that he will know what he is going into. Teaching a particular trade is dangerous, because the conditions of industry are constantly changing. The boy or girl needs to know fundamental processes and types of machines so that he or she may be able to pass from one machine to another and not

[28] BSA-NYC, Record Group: Faculty, Administration, Staff, Box 6, Folder: Arnold, Frances (1898–1930), L. Watson, *Class Notes, Bryn Mawr Bulletin*, 1975.

[29] BSA-NYC, Record Group: Faculty, Administration, Staff, Box 6, Folder: Arnold, Frances (1898–1930), M.S. Scott, *Miss Arnold Retires*, *Brearley Bulletin*, 1930, p. 11.

> stand ignorant and helpless when the old machine is taken out and the new one put in. It is the first duty of the public schools to fit the children for the lives that most of them will live. But they must be taught how to enjoy their leisure.[30]

This debated topic was not only discussed by teachers but was also brought up by the educators on the larger scale, including David Eugene Smith, a key American mathematician who played a significant role in the history of mathematics and the development of mathematics education. Smith was a vocal critic of categorizing secondary school mathematics as an elective, particularly of the argument that it was a subject unnecessary for girls: 'the problem seems to me not so much to decide whether or not the girl should study algebra, as to decide how we shall so teach the subject to her that she will know of its beauties, of its purposes, and of the feeling of mastery that comes from its pursuit. Such a problem may well occupy the attention of associations like the one I have the honor to address'[31].

This issue also extended to higher education institutions. In letters written by Marion Edwards Park, the third President of Bryn Mawr College (1922–1942), she responded to a question about the direction of women's education. The question, as outlined in the letter, asked whether education for girls should be more tailored to the practical needs of the students. In her response, Park thoughtfully addressed this issue, offering insight into her broader views on the role of higher education for women during that era:

> My answer is then rather flatly that I think a school or college can use its time far better in its particular purpose which is to help girls to become intelligent adults as quickly and directly as possible. And that a family can use its time – and it has somewhat more than a third of a year to plan for – in rounding out its daughter's development and experience by teaching her simple and useful skills. And finally, that what the girl hasn't "learned" off her school and her family, she can learn later for herself, spurred on by necessity, by the stimulus that comes from her first real independence.[32]

This perspective reflects a broader critique by educators of curricula that prioritized certain subjects over others, often at the expense of developing well-rounded, intellectually engaged students. Even in later decades, educators voiced concerns about the narrowing focus of education that took place during the Progressive Era, particularly when it came to subjects like mathematics that were traditionally seen as essential to education. An address published three decades after the Progressive Era in "The Mathematics Teacher" summarized the changes that took place during that period as follows:

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[30] H. Rodman, *A.F. of L. and Socialists Attack Curricula of Public Schools*, "New York Tribune" 12.06.1915, p. 7.

[31] D.E. Smith, *Problems in the Teaching of Secondary Mathematics: An Address Delivered Before the New England Association of Teachers of Mathematics*, Ginn, Boston 1913, p. 13–14.

[32] Bryn Mawr College Archives, Park, Marion Edwards Office Files, 1922–1942, Box 3, Bryn Mawr College, Bryn Mawr, PA.

> [The early 1920s were] dominated by the ever more vexing problem of mass education and characterized by a nationwide battle of objectives that has been continued to this day. It led to the creation of thousands of curricula in mathematics alone. A third phase, occupying the decade preceding war, resulted directly from the school; increasingly our time-honored subject was removed from its position of prominence to that of a merely tolerated "elective". And today we are in the midst of a fourth period which will witness either a full elimination of mathematics or its restoration to the place it deserves. In a large number of our states, not a single hour of mathematics is now required for graduation from high school.[33]

Therefore, even though the elective system received criticism and was later rolled back, research on mathematics education should take into consideration the environment that mathematics teachers – especially those teaching girls – faced. During Arnold's tenure as a teacher, New York City schools were facing unprecedented challenges. One personal letter from a Brearley student highlights how the school's math curriculum was needed primarily as a tool for managing a husband's finances, rather than a means to empower women to pursue broader intellectual or professional goals[34]. Therefore, teachers during this time were positioned in an environment where they had to navigate these societal expectations, while balancing the need to provide education in a world that was rapidly changing. These challenges were combined with job market demands, which often influenced the way subjects like mathematics were taught and perceived, reinforcing traditional gender roles.

This work prompts further historical exploration into the complex relationship between gender, mathematics education, and the role of educators. It highlights the importance of considering how different social, cultural, and historical contexts shaped educational practices, rather than relying on a general narrative. Therefore, Frances Arnold's story highlights the importance of examining individual teacher and how one teacher's attitude and beliefs in their students could have influenced them during a time when mathematics education had to be defended in term of its need and efficiency.

Limitation of study

Unfortunately, attempts to locate any personal recollections from Arnold regarding her mathematics teaching experiences have not been successful. However, based on a statement she made about her promotion to headmistress, it seems she may have refrained from discussing her accomplishments, possibly due to her

[33] W. Betz, *Five Decades of Mathematical Reform – Evaluation and Challenge*, "The Mathematics Teacher" 1950, vol. 43, no. 8, p. 377–387.

[34] Barnard College Archives [BCA], Millicent Carey McIntosh Papers, Series 1.1, Box 1, Professional correspondence, *Personal Note*, n.d.

modesty. She is quoted as saying: 'Now, I don't want you to give me any "airs"... I was really just a schoolteacher at Brearley. When the headmistress died suddenly, they asked me to serve as headmistress. And I did, for three years before I retired'[35]. This suggests that she may have been reluctant to speak at length about her achievements.

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