

## DEPARTMENT: BIOGRAPHIES

# The Legacy of Mary Kenneth Keller, First U.S. Ph.D. in Computer Science

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The founding of the first computer science programs at universities in the United States in the early 1960s resulted in 1965 in the first two doctoral-level degrees. On June 7, 1965, Irving C. Tang received a D.Sc. from the Applied Mathematics and Computer Science Department, Washington University, St. Louis. Tang's thesis was entitled "Radial Flow Between Parallel Planes," directed by C. David Gorman of the Mathematics Department. The same day [27], Mary Kenneth Keller received a Ph.D. in Computer Science from the University of Wisconsin, Madison. Ralph London documented this, correcting the historical record [26], [27].

Here, we focus on Mary Kenneth Keller<sup>1</sup> (Figure 1). She was a woman of many names. Born Evelyn Marie Keller, she entered the Catholic congregation of the Sisters of Charity of the Blessed Virgin Mary (BVMs) and was given the name Sister Mary Kenneth. In her publications, she used the name Sister Mary K. Keller [8], [19], [20], [21], [22], [23], Sister Mary Kenneth [25], Mary K. Keller [18], and (her complete name) Sister Mary Kenneth Keller, BVM [24]. In this article, we refer to her as Sister Kenneth.

### LIFE BEFORE COMPUTING

Evelyn Keller was born December 17, 1913, in Cleveland, Ohio, but spent most of her youth in Chicago. Both of her parents had 8th grade educations. She graduated from The Immaculata High School, a BVM school, in 1931. Mary Jerellen Tangney, BVM, wrote in 1932 that Evelyn

<sup>1</sup>This is an abridgement of the biography at <https://arxiv.org/abs/2208.01765>.

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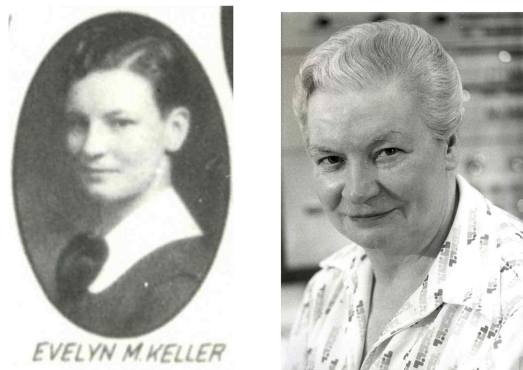
was an excellent student, excelling in English and Journalism. Evelyn entered the BVM congregation in September 1932, at age 18. She was formally received into the community on March 19, 1933, and it was then that her name was changed from Evelyn to Mary Kenneth.

For the next three years, Sister Kenneth focused on spiritual development and also attended Clarke College (Dubuque) and Mundelein College (Chicago), women's colleges founded by the BVMs. After taking religious vows on March 19, 1935, she began her teaching career, assigned for the next 29 years to work in elementary and high schools in Illinois and Iowa. In those times, sisters typically finished their academic degrees "on the installment plan" in summer school so as not to interfere with their teaching assignments. Sister Kenneth took additional courses from Clarke and Mundelein, as well as 13 credit hours from DePaul University (Chicago), which awarded her B.A. in mathematical sciences, with a minor in Latin, in 1943. She took 30 hours of course work at DePaul between 1946 and 1952 to earn an M.S. in mathematics.

### INTRODUCTION TO COMPUTING

As a high school math teacher on the west side of Chicago in her mid-40s, Sister Kenneth "read the signs of the times and as early as 1961 responded by enrolling at Dartmouth College in Hanover, New Hampshire for her first workshop in computer education."<sup>2</sup> As Sister Kenneth told it, "I just went out to look at a computer one day, and I never came back.... It looked to me as if the computer would be the most revolutionary tool for doing math that I could get" [35]. Anthony Knapp, an undergraduate staff member for the summer workshop, recalls that programming of Dartmouth's LGP-30 computer was done in assembly language. The drum memory contained 4096 32-bit words, addressed by track and sector, and arithmetic was

<sup>2</sup>Dolores Marie McHugh, BVM, January 14, 1985.



**FIGURE 1.** Sister Kenneth's high school yearbook photo and a photo from later in life. Photo credits: BVM Archives and Clarke University Archives.

fixed-point. The participants used a sign-up sheet to reserve the computer for their use and completed simple programming tasks, such as playing tic-tac-toe. Contrary to published reports (e.g., [13]), Kurtz wrote that Sister Kenneth "had absolutely nothing to do with the creation of the BASIC computer language,"<sup>3</sup> first released in May 1964.

## PH.D. STUDY

In the early 1960s, Mary Benedict Phelan, BVM, president of Clarke College, decided that students should prepare for the information age. Sister Kenneth was sent to the University of Wisconsin, Madison (1962–1965), to complete a Ph.D. degree in order to lead this program. Her break in teaching assignments was only one year, 1964–1965, so again much of her study must have been during summers. She completed 15 credit hours in computer science and 21 credits of research, supported by a National Science Foundation Fellowship (1962–1964) and then by a university fellowship. Her academic advisor was Preston Hammer, Professor of Numerical Analysis and (as of 1964) Professor of Computer Science.

Sister Kenneth began her dissertation [24], "Inductive Inference on Computer Generated Patterns," with the declaration, "The basic problem of this thesis is the exploration of an approach to the mechanization of inductive inference." The idea was to automatically generate the  $n$ th mathematical expression in a series, given the first  $k$  expressions. As validation, Sister Kenneth implemented a FORTRAN program to determine the  $n$ th derivative of a function, given the first  $k$  derivatives. (She remarked that list processing languages such as LISP would have been more convenient but

were not available to her.) She wanted to demonstrate that algorithms could perform tasks like differentiation through learning-by-example, rather than by a rule-based process. Although this approach was out of favor for many years, it has recently had a renaissance in so-called "deep learning models" in artificial intelligence and now dominates the field. Sister Kenneth did not claim that her "results obtained in the domain of analytic differentiation were important in themselves," but that they demonstrated that her programs "do mechanize an inductive inference....accomplished in less than 30 seconds per problem" [24, pp. 46–47].

She concluded with her first statement on the relation between human and artificial intelligence: "The claim that this parallels the activity of the mathematician who generalizes on a symbol manipulation routine after some number of repetitions must, of course, be qualified" [24, p. 46].

The thesis was signed on May 21, 1965, by Preston Hammer, Ralph L. London, (programming languages and verification), and Eldo Koenig (man-machine interactions and robotics). The "major department" is listed as "Computer Sciences" and the minor as "Mathematics" [24, p. 67]; see Figure 2. She listed membership in the Society for Industrial and Applied Mathematics (SIAM), the Association for Computer Machinery (ACM), and the Mathematical Association of America (MAA).

After 29 years of K-12 teaching and 33 years of college-level studies, Sister Kenneth had finally completed her formal education. She was 51 years old.

## WORK AT CLARKE COLLEGE

Sister Kenneth arrived at Clarke College with a vision: "Automation, or more precisely, cybernation, is a fact of our lives. Its impact is swift and in many ways silent. Our sense of responsibility should make us wish to be informed and to inform our students.... Furthermore, the computer can give a new dimension to the education we offer" [29]. She was appointed head of the "Center for Computer Sciences" at Clarke, in charge of a desktop computer, the Bi-Tran Six, (Figure 3) with 128 6-bit words of memory, visible circuit boards, and programming in assembly language [12]. An IBM 1130 with 8 K memory and paper tape reader was installed in 1966, later upgraded to punched card input. Keeping the computer facility up-to-date on a shoe-string budget was a continuing struggle, absorbing much of her time and effort.

In addition to managing academic and administrative computing at Clarke, Sister Kenneth kept her hand in research; in 1975, she was collaborating with Raymond Martin at Wartburg Theological Seminary, using the computer to compare the Hebrew, Aramaic, and Greek texts of two books of the Bible [35], research that was related to Martin's previous work [28].

<sup>3</sup>Thomas Kurtz, January 11, 2019 email.

**TITLE OF THESIS** INDUCTIVE INFERENCE ON COMPUTER GENERATED PATTERNS

**Full Name** Sister Mary Kenneth Keller, BVM

**Place and Date of Birth** Cleveland, Ohio Dec. 17, 1913

**Elementary and Secondary Education**

Cleveland and Chicago Parochial Schools

Immaculate High School, Chicago, Illinois

**Colleges and Universities: Years attended and degrees**

Clarke College 1933-35 Mundelein College 1935

De Paul University, Chicago 1942-1952 A.B. 1943, M.S. 1952

Purdue University 1957 Dartmouth College 1961

University of Wisconsin 1962-65 Ph.D. June 1965

**Membership in Learned or Honorary Societies** Society for Industrial and Applied Mathematics

Association for Computing Machinery

The Mathematical Association of America

**Publications**

**Major Department** Computer Science

**Minor(s)** Mathematics

**Date** May 21, 1965

**Signed** *Dwight C. Hammer*  
Professor in charge of thesis

FIGURE 2. Page 67 of Sister Kenneth's thesis [24].

Under Sister Kenneth, the computer center was a family-friendly environment. After Kathy Decker (Clarke '74) was hired, despite the cramped quarters, Sister Kenneth provided nursing and play space for her children [5].

By 1978, Sister Kenneth advocated using microprocessing technology in place of large, central computing systems.<sup>4</sup> In 1980, she received an NSF grant to equip a lab with 20 microcomputers, shown in Figure 4, for classroom use. The machines could be configured with color

graphics, sound, light pens, plotters, and more, one more step toward serving liberal arts students. The newly named Keller Computer Center [6] had tripled in size from its original classroom [29] to 2750 square feet [10] reclaimed from Clarke's laundry building, and had an IBM 4331 with a megabyte of memory [33]. By 1982, there were 21 Apple computers on campus.

### Contributions to Clarke College Education

Sister Kenneth became an evangelist for computer science, determined that the women graduating from Clarke

<sup>4</sup>Sister Kenneth letter to M.C. Rayner, May 12, 1978.



**FIGURE 3.** Sister Kenneth with Bi-Tran Six computer. Photo credit: Clarke University Archives.

would be ready for the computer age. Until 1968, she was “a one-woman computer sciences department” [9]. Immediately upon taking her position at Clarke in Fall 1965, Sister Kenneth initiated a 3-credit-hour introductory course and established a minor concentration in computer science, a first for private colleges in Iowa. She initially did not want a computer science major, believing that the liberal arts should be encouraged.<sup>5</sup>

“Sister Computer” noted in 1965 that a broad mathematical background was not necessary to study computing; essential qualities were confidence, humility, and patience. “The computer does not make mistakes, and it is hard on one’s ego to have to assume all the blame every time something goes wrong. That is where humility comes in and then you get to practice patience by correcting your mistakes” [29].

Sister Kenneth was a gifted teacher and communicator, even tutoring R. (Richard) Buckminster Fuller (designer of the geodesic dome) (Figure 5). Fuller said, “I wondered if I’d be able to do this successfully at the age of 73,” but he found that he could, “slowly” [31]. “He believed that technology should be directed to ‘livingry’ rather than to military power and weaponry” [5], a view shared by Sister Kenneth.

<sup>5</sup>Mary Louise Caffery, BVM, July 2, 2019.



**FIGURE 4.** Sister Kenneth in Clarke’s Computer Center in September, 1980. Photo: Reprinted with permission of the *Dubuque Telegraph Herald*.

Sister Kenneth was a witty teacher, engaging each person as she walked around the room. In addition to regular courses, she taught evening adult education in FORTRAN and assembly language. She “coerced” her academic colleagues into learning computing, telling artists and musi-



**FIGURE 5.** “73-year-young R. Buckminster Fuller is taking a two-day crash course in computer science and programming from Sister Mary Kenneth” [11]. Photo credit: Clarke University Archives.

cians, “You have to know this!”<sup>6</sup> She got them “hooked up on that Apple computer,” and even told IBM representatives that they needed to build a machine like that, rather than just producing large mainframes. She was “just so pleased if people used the computer in a new way.”<sup>7</sup>

In 1973, Sister Kenneth moved from teaching into full-time administration. In 1977, a merger at Clarke created the Department of Computer and Management Sciences, with a Women in Management Program to integrate the disciplines. This doubled the size of the faculty, from two to four. Clarke established a Bachelor of Arts degree in 1979, with 7 graduates in 1980. The students were quite successful in finding work-study positions, summer jobs, and permanent positions [4]. A Bachelor of Science degree was added in 1982. By that time, Computer Science at Clarke had 51 students, including 30 masters candidates [1].

Sister Kenneth continued her advocacy for computer education in secondary schools, running NSF Summer Institutes in Mathematics for Secondary School Teachers from 1968 to 1972. In 1981, Clarke established a summer Masters Program in Computer Applications in Education, “among a very few such programs nationwide” [1]. Fifty students made up the first cohort, completing 9–12 credit hours in education, 15–18 in computer science, and 3–6 in electives. David Fyten, a Clarke faculty member, said, “Many teachers feel that the introduction of microcomputer education has rejuvenated their desire to stay in teaching.”

In the January 1983 semester, Computer Science ran 10 courses with 19 sections averaging 25 students per section, taught by five FTE instructors. Sister Kenneth was asked to prepare a 5-year plan for the computer center. She complied but noted that it “can only be a projection from the present, and not too real. Consider that five years ago almost nothing that is in the center today existed. The field is in even greater flux today.”<sup>8</sup> She did know one thing with certainty: “A search for a new director of the computer center should be started,” since she was dealing with breast cancer after surgery in August 1982, and knew that she needed to retire.

## COMMUNITY SERVICE

### Service to Industry

During the late 1960s, Sister Kenneth established herself as a local expert on computing hardware, software, and applications. She was much in demand by local government [33] and industry (e.g., Figure 6) and responded by organizing seven Iowa Technical Service Seminars for Business and Industry and by consulting for companies



**FIGURE 6.** Sister Kenneth at an August 2/3, 1967 conference at Clarke College on Hospital and Medical Applications of Computers. Photo credit: Clarke University Archives.

ranging from from Ertl Toy Company to Magma Copper Mines. “People called her up, and she solved their problems.”<sup>9</sup> The relationships she developed supported Clarke in the 1970s, for example, through the donation of a used IBM 360-40 and through contracts, such as one to develop software for John Deere Dubuque Works. “Almost single handed she equipped the computer lab by giving lectures in colleges and universities, conferences, conventions, lunches, dinners, wherever she could reach an audience and be paid to do it” [33]. In those lectures, Sister Kenneth often put considerable emphasis on ethics, saying that computers should be used to alleviate poverty and ignorance and to open up new possibilities in industry rather than replacing current workers [3].

In a 1967 speech on “Computer Applications from a Management Point of View,” Sister Kenneth noted that advances were hampered by a shortage in computer programmers and by dataflow restrictions within companies:

The concept of a database where all items are organized on a tree with interconnected branches would seem to be the correct principle of operation for the future,... a complete departure from the structuring of data files in the traditional sense where a payroll file belongs to one department and a separate personnel file [exists] for the use of the personnel department.... There will likely be a greater use of... visual display output which is meant to be a momentary presentation of information for view by the executive on an on-call demand basis,

<sup>6</sup>Carol Blitgen, BVM, July 2, 2019.

<sup>7</sup>Mary Louise Caffery, BVM, July 2, 2019.

<sup>8</sup>January 25, 1983 memo

<sup>9</sup>Mary Louise Caffery, BVM, July 2, 2019.

whereas the hard copy output will be limited to traditional reports and output documents.

She also highlighted the use of computers in process and production control and in simulation. All of this depended on a sufficient supply of knowledgeable programmers, and she established a pipeline of educated candidates from Clarke and other small colleges and universities.

### Service to Education

Sister Kenneth was a founding member of the College and University Eleven-Thirty Users Group (CUETUG) which, as IBM 1130s were retired, was renamed the Association of Small Computer Users in Education (ASCUE). She spoke at their meetings (e.g. [15], [16], and [17]) and represented ASCUE on the steering committee for the National Educational Computing Conference. She served as a Board member (1974–1976) and as Public Relations Director (1977–1984) until shortly before her death.<sup>10</sup> Sister Kenneth was active in ACM's Curriculum Committee for Undergraduate Computer Science and worked on the Masters-level curriculum. She spoke at many professional meetings and consulted on curricula and computer facilities for small colleges (e.g., [14]). The highly influential ACM *Curriculum'78*, a model for undergraduate computer science education, lists her as a contributor [2, p.166]. In April 1980, she testified before Congressional subcommittees on information technology in education.

The IEEE Computer Society honored Sister Kenneth by establishing the Mary Kenneth Keller Computer Science & Engineering Undergraduate Teaching Award, which has been given most years since 1999.<sup>11</sup>

## TEXTBOOK AND EDUCATIONAL MODULES

### Textbook

Sister Kenneth collaborated on a 1973 textbook [8] based on an earlier textbook by Dorn and Greenberg entitled *Mathematics and Computing with FORTRAN Programming* [7]. The newer version omitted applications in linear algebra and calculus and used the more accessible BASIC programming language in order to reach a broader audience.

Sister Kenneth's contributions began with a 43-page introduction to BASIC programming [8, Sec. 1.1–1.13 and 2.4], developing the ideas of an algorithm, flow-chart, and code through the solution of two linear equations. Then, she systematically taught the language.

Her attempts to prevent student errors were remarkable; for example, she carefully explained the rather confusing rules for variable and array names. The level of clarity was noticeably higher than that of the following section about computer arithmetic, taken from Dorn and Greenberg.

Sister Kenneth's approach to pedagogy is most evident in the book's Appendix A, where she stepped students through their first encounter with using a teletype, from sign-on to sign-off. It seemed important to her to provide students with every piece of information they would need to succeed.

Two other sections by Sister Kenneth complemented the discussion of and-or-not computer circuits by introducing truth tables and Karnaugh maps.

A final section explains how to use random numbers to run simulations, using a baseball batter's history as an example.

### Work With UMAP

Following a 2-week curriculum development meeting in Massachusetts in 1975 [33], Sister Kenneth wrote several educational modules for the Undergraduate Mathematics and Its Applications Project (UMAP). "The goal of UMAP is to develop, through a community of users and developers, a system of instructional modules in undergraduate mathematics and its applications that may be used to supplement existing courses and from which complete courses may eventually be built" [22, face-page]. Sister Kenneth structured her contributions in pairs, one elementary and one more advanced. She included exercises, a sample test, answers, and computer programs. She aimed to make the modules attractive to students by choosing topics of interest.

Modules U105 and U109 [23] concerned food service management. In the elementary module, she showed how to compute the cost of various menu items from ingredient costs and recipes. In the advanced module, she invited the student to create a diet that met specified nutritional requirements.

Module U106 [22] concerned computer graphics. Sister Kenneth explained the process of rotating a ray in the plane through a specified angle by multiplication by a  $2 \times 2$  rotation matrix. Then, she introduced homogeneous coordinates, three coordinates for each point in the plane, a common choice in computer graphics. Continuing this theme in Module U110 [22], Sister Kenneth invited students to determine how to rotate, translate, and scale points in 3-D using homogeneous coordinates.

Modules U107 and U111 [21] introduced Markov chains. Using an example of predicting student performance based on performance on a previous exam, Sister Kenneth introduced the transition matrix and its uses. In the advanced module, using an example of television viewing habits, she introduced the stationary vector of

<sup>10</sup>[Online]. Available: <https://ascue.org/history/>

<sup>11</sup>[Online]. Available: <http://www.computer.org/volunteering/awards/cse-undergrad-teaching>

the chain, the long-term probabilities of the model. Another example involving loan repayment prediction, which has absorbing states, motivated the fundamental matrix of the chain.

Module U108 [20] presented Kirchoff's laws and Ohm's law with a system of linear equations to analyze a (linear) electrical circuit. Module U112 [20] dealt with more complicated circuits.

## SISTER KENNETH'S PHILOSOPHY OF COMPUTING

In her unfinished book entitled, *The Computer: A Humanistic Approach*, Sister Kenneth viewed the computer as an "idea processor" for text and programs that should be used in schools as early as the fourth grade. She meant to provide a source of interesting elementary, intermediate, and advanced problems amenable to computer solution, especially with "pictorial and graphical representations for solutions."

Sister Kenneth was a visionary. Her colleagues were in awe of her, astounded by prescient predictions that wristwatches would become computers<sup>12</sup> and that computers would transform the arts and humanities. As early as 1966, she envisioned the use of computers in every academic discipline:

We really do not know how people learn. For the first time, we can now mechanically simulate the cognitive process. We can make studies in artificial intelligence. Beyond that, this mechanism can be used to assist humans to learn. It reacts patiently, persistently. It can store the number of paths a student may take, and point out the successes....In the modern linguistic field, for instance, the whole science of language and grammar may be studied by this method [30].

She was also aware of the fears that jobs would be eliminated and automated decisions would be unquestioned, as well as the hopes of more meaningful work and "a super-planner, which can aid the world's growing population in production, protection, and decision. It is reasonable to stand with those who hope, but it must be with a sense of responsibility," since "man has not always used his inventions well" [25].

Perhaps her most complete exposition of her philosophy was presented in an undated address to the Cedar Rapids Conference on "The Role of the Computer in the High School." She pointed out the computer's potential as a teaching machine, librarian for information retrieval, "super-clerk" for reducing the

monotony of administrative tasks, and linguist for foreign language translation.

Of course it is a mathematician, but please do not think of it as just a special adding machine or even a super slide rule. It is just a historical accident that such connotation [is] attached. It is essentially a symbol manipulator.

She envisioned the computer improving education and freeing teachers to have "more human contact with your students and fellow teachers." Sister Kenneth gave an emphatic "yes" in answer to the question of whether computation should be taught in high school:

Every citizen has a right and a duty to have a knowledge, commensurate with his capacity, of the important forces and instruments which shape his civilization. Not only, as I have said, would we be presenting a distorted, truncated view of subject areas [if computation were omitted], but we would be failing to capitalize on the ease of introducing basic concepts to young adults as compared to mature adults, and we would be denying many that knowledge altogether.

She believed that every high school student should be able to program a computer and to understand its internal binary logic system. Rather than separate courses in computing, Sister Kenneth envisioned a "mathematics laboratory" accessible "to every mathematics student regardless of level." On the practical side, she anticipated that the reaction of those in the audience might be "there are no funds, and that takes care of that." She noted, "This is a situation in which the experiences of life makes me a minor expert." To convince them, she had collected positive responses from potential donors in the Dubuque area. Regarding teacher training,

The number of such courses that are available at many colleges is yearly increasing, and a single course is sufficient to bootstrap teachers into a program of self-education.... Education is, after all, a self-activity, and a patient but unrelenting electronic assistant can be a boon.

## FINAL DAYS

Sister Kenneth was true to her mission to the end. A sign in her office read, "My life is a continuing changing awareness of God's will for me" [35]. Catherine Dunn, BVM remembers that even as Sister Kenneth was dying in a nursing home, she had a computer in her bedroom. She continued to work, plan nutritious meals [33], and give lessons to other sisters (Figure 7) [34]. Sister Kenneth did not want to die: she felt she still had work to do.

<sup>12</sup>Carmelle Zserdin, BVM, July 2, 2019.

Nevertheless, Bertha Fox, BVM, reports that her last words were, “Yes, yes.” She died January 10, 1985.

Her gravestone at Mount Carmel, shown in Figure 8, is small, flat to the ground, and shared with another sister. It has her name and the three most important dates of her life: birth, entrance into the BVM congregation, and death.

## CONCLUSION

Sister Kenneth was a totally remarkable woman. She made the most of every opportunity given to her, even her unlikely path to her late-in-life Ph.D. As a scholar, she has the distinction of being an early advocate of learning-by-example in artificial intelligence. Her main scholarly contribution was in shaping computer science education in high schools and small colleges. She was an evangelist for viewing the computer as a symbol manipulator, for providing computer literacy to everyone, and for the use of



**FIGURE 7.** Sister Kenneth (right) in April, 1984, demonstrating computing to BVM sisters Gladys Ramaley and Marian Delany. Photo Credit: Reprinted with permission of the *Dubuque Telegraph Herald*.



**FIGURE 8.** Shared gravestone at Mount Carmel, Dubuque, Iowa. Photo: T. J. O’Leary.

computers in service to humanity. She was far ahead of her time in working to ensure a place for women in technology and in eliminating barriers preventing their participation, such as poor access to education and daycare. She was a strong and spirited woman, a visionary in seeing how computers would revolutionize our lives.

## ACKNOWLEDGMENTS

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## BIBLIOGRAPHY

- [1] “Clarke College offers masters program,” *Apple Educ. News*, vol. 3, no. 3, Oct.–Dec. 1982.
- [2] R. H. Austing, B. H. Barnes, D. T. Bonnette, G. L. Engel, and G. Stokes, Eds., “Curriculum ’78: Recommendations for the undergraduate program in computer science,” *Commun. ACM*, vol. 22, no. 3, pp. 147–166, Mar. 1979.
- [3] J. Byrne, “Expert urges computer familiarity,” *Chicago Sun Times*, Jan. 1966.
- [4] “Clarke College receives a \$206,676 National Science Foundation grant,” *Clarke College Comput. Sci. Dept. Newsletter*, Summer, 1980.



- [5] "Sister Kenneth Keller's legacy," in *Clarke College On Campus*. Spring 1995.
- [6] "Computer Sciences Department celebrates 25 years," *Clarke Comput. Sci. Bull.*, 1990.
- [7] W. S. Dorn and H. J. Greenberg, *Mathematics and Computing With Fortran Programming*. Hoboken, NJ, USA: Wiley, 1967.
- [8] W. S. Dorn, H. J. Greenberg, and Sr. M. K. Keller, *Mathematical Logic and Probability With BASIC Programming*. Boston, MA, USA: Prindle, Weber & Schmidt, Inc., 1973, 216 pages.
- [9] "The nun and the computer," *Dubuque Telegraph Herald*, Oct. 1965.
- [10] "Clarke unveils computer center," *Dubuque Telegraph Herald*, Sep. 1980.
- [11] "Famed scientist learns new skill here," *Dubuque Telegraph Herald*, Sep. 1968.
- [12] Educational Services Department, Fabri-Tek, "Computer education: An answer to the challenge!" Accessed: Jan. 25, 2020. [Online]. Available: [https://archive.org/details/TNM\\_Computer\\_education\\_BI-TRAN\\_SIX\\_-\\_Fabri-Tek\\_20171010\\_0075/page/n15](https://archive.org/details/TNM_Computer_education_BI-TRAN_SIX_-_Fabri-Tek_20171010_0075/page/n15)
- [13] D. W. Güler, "Pioneering women in computer science," *Commun. ACM*, vol. 38, no. 1, pp. 45–54, Jan. 1995.
- [14] M. K. Keller, "Experience with various alternatives in undergraduate computing facilities," in *Proc. 1st Conf. Comput. Undergraduate Curricula*, 1970.
- [15] M. K. Keller, "The professional development of student programmers through field experience," in *Proc. 7th Annu. CUETUG Meeting*, Greenville, SC, USA, 1974.
- [16] M. K. Keller, "A business-oriented computer science curriculum," in *Proc. 10th Annu. ASCUE Meeting*, Reading, PA, USA, 1977.
- [17] M. K. Keller, "Microcomputers as a versatile alternative to time sharing in education," in *Proc. 13th Annu. ASCUE Meeting*, 1980.
- [18] M. K. Keller, "The role of a computer science department in the use of the computer in undergraduate curricula at a small liberal arts college," *Proc. Conf. Comput. Undergraduate Curricula, Claremont, CA*, 1973, 6 pages.
- [19] Sr. M. K. Keller, "The role of the university computer center in educational research (with remote hope)," *ACM SIGUUC Newslett. (Special Int. Group Univ. Comput. Centers)*, vol. 4, pp. 12–14, 1974.
- [20] Sr. M. K. Keller, *Electrical Circuits (Unit 108) and Applications of Matrix Methods: Analysis of Linear Circuits (Unit 112)*. 1978, 34 pages.
- [21] Sr. M. K. Keller, *Markov Chains (Unit 107) and Applications of Matrix Methods: Fixed Point and Absorbing Markov Chains (Unit 111)*. 1981, 33 pages, In [32].
- [22] Sr. M. K. Keller, *Computer Graphics (Unit 106) and Applications of Matrix Methods: Three Dimensional Computer Graphics and Projections (Unit 110)*. 1983, 43 pages, In [32].
- [23] Sr. M. K. Keller, *Food Service Management (Unit 105) and Applications of Matrix Methods: Food Service and Dietary Requirements (Unit 109)*. 1983, p. 27, In [32].
- [24] Sr. M. K. Keller, BVM, "Inductive inference on computer generated patterns," Ph.D. thesis, Comput. Sci., Univ. Wisconsin, Madison, WI, USA, Jun. 1965.
- [25] Sr. M. Kenneth, "Man and machine—in that order," *BVM Vista*, pp. 24–25, Dec. 1964.
- [26] R. London, Additional Information for Who Earned First Computer Science Ph.D.? Dec. 2012. Cited in [27].
- [27] R. London, *Who earned first Computer Science Ph.D.?* Jan. 2013. [Online]. Available: <https://cacm.acm.org/blogs/blog-cacm/159591-who-earned-first-computer-science-ph-d/fulltext>
- [28] R. A. Martin, *Syntactical Evidence of Semetic Sources in Greek Documents*. Society of Biblical Literature, 1974. Reprinted by Wipf and Stock Publishers, Eugene, OR, USA, 2004.
- [29] Sr. M. Michail, BVM, "Clarke computers, cybernetics," *BVM Vista*, pp. 26–28, Mar. 1966.
- [30] "Needed: Women to run computers," *Midwest Magazine, The Chicago Sun Times*, Feb. 1966.
- [31] J. Ney, "It's back to school for genius, 73," *De Moines Morning Register*, Sep. 1968.
- [32] Sr. M. K. Keller, *UMAP Modules and Monographs in Undergraduate Mathematics and Its Applications Project*. Bedford, MA, USA: Consortium for Mathematics and Its Applications, 2022. [Online]. Available: [www.comap.com](http://www.comap.com)
- [33] D. Walsh, BVM, "Kenneth Keller, BVM, 1913-85 still being quoted," *BVM Newslett.*, vol. 39, no. 1, Oct./Nov. 2003.
- [34] K. Walsh, "Older nuns learn new tricks on computers," *Dubuque Telegraph Herald*, Apr. 1984.
- [35] "I went to look at a computer one day," *The Witness*, Nov. 1975.

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