

THE MOORE METHOD: ITS IMPACT ON FOUR FEMALE PhD STUDENTS

A RESEARCH PAPER

SUBMITTED

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The purpose of this study was to investigate R. L. Moore and the teaching method he implemented at the University of Texas – Austin, the Moore method. Extensive descriptions of the Moore method exist, but accounts of the Moore method in connection with the impact it had on Moore’s female PhD students are harder to find in the literature. This study examines the Moore method and the accomplishments of Moore’s female PhD students, and analyzes whether or not Moore would have referred to these women as successful graduates. Additionally, this study investigates whether or not his female PhD students attributed their success to their work with Moore and whether or not they viewed him as a successful adviser and professor.

R. L. Moore graduated with a PhD from the University of Chicago in 1905. Oswald Veblen and E. H. Moore advised him on his dissertation in *Sets of Metrical Hypotheses for Geometry*. From there he took an appointment at the University of Pennsylvania, where he advised three PhD students and laid the foundation for what later would be known as the Moore method. Moore spent the rest of his career at the University of Texas – Austin advising an additional 47 PhD students and implementing the Moore method (Zitarelli, 2004).

It is important to recognize the attributes of the Moore method as it will give us criteria to establish Moore’s definition of success. The Moore method was established before students walked into the class on the first day. Students were in a sense selected to enroll in the class based on Moore’s idea of what would create a homogeneously-ignorant class. In addition, he selected students he saw as having potential to be dedicated, serious PhD candidates. Competition was the driving force of the class. Students were forbidden to complete outside readings from texts, listen to lectures, or read any other texts. They were instead forced to build mathematics from the initial definitions, axioms, and theorems that Moore gave them. He then called on students in a reverse ability order to create mathematical proofs. When a student got stuck or had the wrong thought, a more capable student would attempt to complete the proof (Jones, 1977). Additionally, if no one in the class was prepared to demonstrate a proof, Moore led discussions on topics of interest to him. Thus, the class was defined by whatever Moore deemed appropriate (Albers, Reid, & Rudin 1988).

We can gain some insight from Moore's own words into his method through a letter to one of his former female PhD students, Mary-Elizabeth Hamstrom. The correspondence occurred after Hamstrom was accepted to the graduate program in mathematics at the University of Texas – Austin in 1948. She wrote to Moore asking for summer reading recommendations to keep her sharp for her first year as a graduate student. Moore responded with a six-page letter describing his method and beliefs as to why she should not be reading about mathematics, but instead be doing mathematics (Parker, 2005).

He wrote:

to read a proof of a theorem or to *listen* to someone like a professor prove it is very different from proving it yourself without any such assistance... you are thereby acquiring *information* (of a sort) but depriving yourself of the opportunity to work it out for yourself and thereby, perhaps, to develop much more *power* instead of acquiring that much more *information*. (As cited in Parker, 2005, p. 246)

Moore's letter not only gives us insight into the specifics of his method, but it also shows the seriousness and dedication he gave to each of his PhD students.

The Moore method was witnessed by numerous women in the classroom and sixty PhD students. The four female PhD students we will focus on are Anna Mullikin, Harlan Miller, Mary Ellen Rudin, and Mary-Elizabeth Hamstrom (Parker, 2005). Anna Mullikin received her BA from Goucher College, and went on to teach mathematics at the Science Hill School. She continued her career at the University of Pennsylvania, where she produced initial research in point-set topology. Moore even arranged for her to take an interim instructorship at the University of Texas – Austin so that she could continue her research with Moore after he switched universities. Mullikin received her PhD in 1922 (Bartlow & Zitarelli, 2009). Following Mullikin, roughly twenty years later, Harlan Miller was Moore's second female PhD student. Miller taught at the Hockaday School in Dallas, Texas prior to entering

graduate studies with Moore. She received her PhD in 1941 at the age of forty-five, completing her dissertation on compact unicoherent continua (Parker, 2005).

Moore's third female PhD student was Mary Ellen Rudin, who met Moore on her first day as an undergraduate student. Moore picked her out as a future PhD student in mathematics before she even knew which classes to sign up to take her first semester at college. He remained her only mathematics professor up until her senior year of college, and then advised her through her PhD program as she proved to be a successful mathematician, graduating with her doctorate in 1949 (Albers, Reid, & Rudin, 1988).

Lastly, we discuss is Mary-Elizabeth Hamstrom, who was taught by two of Moore's former PhD students. She studied under Dr. Mullikin at the high school level, and Dr. Kline at the undergraduate level. Dr. Kline studied with Dr. Mullikin under Dr. Moore at the University of Pennsylvania. Hamstrom completed her graduate program with Moore in 1952, researching topics concerning webs in a plane (Parker, 2005)

These four women all successfully passed through Moore's rigorous program of mathematical education; however, they found it harder after graduation to align themselves with his idea of success. Based on the characteristics of Moore that have been established, we can isolate several criteria Moore used to determine if his female PhD students were successful. They would: not marry, take a full-time university appointment upon completion of the PhD, and produce ongoing research in the field of mathematics. Evidence for Moore's non-marriage criterion is seen in his response to Mary Ellen Rudin (née Estill) when he discovered her engagement to Walter Rudin. He stated, "Husband! But, Miss Estill, I thought that you were going to be a mathematician" (Albers, Reid, & Rudin, 1988, p. 124).

Evidence that Moore used a criterion regarding taking a full-time university appointment is witnessed by the disappointment Moore felt when Mullikin went back to teaching high school mathematics upon completion of her doctorate studies. Moore was reported to have been left

heartbroken when Miss Mullikin “wasted her talents” to become a high school math teacher (as cited in Parker, 2005, p. 243). Finally, support for Moore’s criterion of maintaining an active research program in mathematics is evidenced by the disappointment Moore had in response to neither Mullikin nor Miller producing research after their exceptional and promising dissertations (Parker, 2005).

We can now use these criteria to determine how Moore might have viewed the accomplishments of his female PhD students. Additionally, we will also look at evidence to determine whether or not these women held favorable views regarding the experience and work with Moore. It is important to not only recognize the accomplishments of these women and how Moore viewed these accomplishments, but also to examine to what extent these women attributed their success to their work with Moore. John Worrell, a former PhD student of Moore, certainly gave Moore credit for cultivating mathematical success, stating that:

I venture to speculate on the basis of my experience that Moore developed ability that was not there, and I’m trying to make a simplistic statement that you could take persons of grossly compromised intelligence and bring them to the level of someone like Mary Ellen Rudin. I think he developed it. I think there was something in Moore and the way he approached things that caused things to take place in the brain. (Parker, 2005, p. 303)

It is important to start by examining Moore’s first female student, Anna Mullikin, to determine her accomplishments. She was considered one of the earliest researchers in point-set topology. Additionally, her former students viewed her as an excellent high school teacher and mentor who pushed her students with a fine balance of gentle seriousness to continue their learning at higher levels. For example, she encouraged her student Mary-Elizabeth Hamstrom to continue her work in mathematics at the university level. Additionally, she helped to write two algebra books (Bartlow & Zitarelli, 2009). However, it is known that she will always be seen as breaking Moore’s heart when she continued to teach high school instead of remaining at institutions of higher learning. We have to

believe Anna Mullikin thought highly enough of Moore to follow him to Texas and recommend students like Hamstrom to work with him (Parker, 2005).

Harlan Miller went on to teach at the Texas Women's University. The university currently holds an annual Harlan Miller lecture series in her honor. However, in Moore's view she never continued to produce research after her dissertation. Miller helped Lida K. Barrett to study with Moore and advised J.R. Boys who later went on to develop a Moore-style mathematics program at Guilford College (Parker, 2005).

Mary Ellen Rudin, one of Moore's more renowned students, took a job Moore arranged for her at Duke and several other part time appointments (Parker, 2005). Over the years she has contributed major developments in general topology research as she stated that she has "never minded doing mathematics lying on the sofa in the middle of the living room with the children climbing all over me..." (as cited in Parker, 2005, p. 133). Additionally, she was the vice president of the American Mathematical Society and advised fifteen PhD students (Albers, Reid, & Rudin, 1988). While she did meet the criteria laid out regarding producing ongoing research in the field of mathematics, we are forced to wonder what Moore would have thought about her decision to get married and never committing to a full time university appointment.

Rudin also had an interesting view of Moore. She regretted being used as a "killer" in the class, as she was forced to complete the proofs of the students who could not finish the work (Albers, Reid, & Rudin, 1988). Additionally, her torn view on Moore can be seen in the statement:

I'm a child of Moore. I was always conscious of being maneuvered by him. I hated being maneuvered... He maneuvered you in order to build your ego. He built your confidence that you could do anything. No matter what mathematical problem you were faced with, you could do it. I have total confidence to this day. (As cited in Albers, Reid, & Rudin, 1988, p. 122)

Additionally, she has also been quoted that she refused to teach any of her students in the manner she was taught in by Moore (Parker, 2005). She felt deprived of a standard curriculum that other programs offered (Albers, Reid, & Rudin, 1988).

Mary-Elizabeth Hamstrom took an appointment at the University of Illinois researching geometric topology. She directed nine PhD students there (Parker, 2005). Her decision whether to get married was never mentioned. Thus by the criteria stated, we have to believe Moore would have viewed her as a success. She, on the other hand, had “very mixed emotions about the whole experience” (Parker, 2005, p. 250). She regretted the competitive nature of the class and the effect it had on the less capable students; however, her appreciation for the opportunities he gave her can be seen in the following quote:

I went there wanting to be a mathematician. I guess I thought I was becoming one sooner because I was sitting there doing it myself, and we all had the impression that we were pretty serious mathematicians already, not that we were going to get a degree and then be a mathematician. We thought we were hot shots right there and then. It’s just that his idea was the business of getting a degree is doing something original in mathematics and we realized we were getting training in doing something original in mathematics... His main interest was in having us do the mathematics, and so we did it, and we were very serious about our work. (As cited in Parker, 2005, p. 249)

Thus, as we have seen, Moore developed a rigorous system for selecting and developing talent in mathematics. Once students were chosen to complete doctoral degrees with him, Moore was emotionally involved and extremely dedicated into making them into successful mathematicians (Jones, 1977). However, his view of success sometimes conflicted with the role of women during that time period, as they were commonly seen as the homemaker not having time to dedicate towards a

profession (Henrion, 1997). At a time when women were still struggling to be seen as equals Mary Spencer stated that:

I did not become a professional mathematician. As with most women, most of my energies have been directed towards the home and children. But I think it is true that I see farther into the world, and understand better what I see, because of the work I was privileged to do for you [Moore]. (As cited in Parker, 2005, p. 256)

In this letter that she writes to Moore twenty-six years after working with him, she is able to describe the reason most women struggled to pursue a career in mathematics (Parker, 2005). The common view at that time was that they were forced to choose between the home life and the professional career (Henrion, 1997). However, looking at four of his six female PhD students allows the reader to get a glimpse of women who were able to overcome these stereotypical roles of women during the mid-1900s. Furthermore, while several of these women made great academic accomplishments, Moore may not have seen them in the same light of success as we might today. Additionally, it is also important to recognize the different views, most of which were divided, regarding what light in which the women viewed Moore (Parker, 2005).

Moore's own words, found in correspondence and interviews, allow us to create a working definition of his idea of success. In order to find out more about the views of Moore's female students about their own success and the role they believe Moore played in it, a further study could be conducted by writing letters to his female PhD students (who are still alive). Additionally, there were two female students that Moore advised in the later part of his career. However, there is not much if any literature available on these women (Zitarelli, 2004). Thus, contacting these women (who are also still alive) would give additional perspectives on the complicated relationship Moore's female students had with his ideas of success and with Moore himself.

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