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Alicia Boole Stott, a geometer in higher dimension

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Abstract

In this paper we present the life and work of Alicia Boole Stott, an Irish woman who made a significant contribution to the study of four-dimensional geometry. Although she never studied mathematics, she taught herself to "see" the fourth dimension and developed a new method of visualizing four-dimensional polytopes. In particular, she constructed three-dimensional sections of these four-dimensional objects, which resulted in a series of Archimedean solids. The presence in the University of Groningen of an extensive collection of these three-dimensional models, together with related drawings, reveals a collaboration between Boole Stott and the Groningen professor of geometry, P.H. Schoute. This collaboration lasted more than 20 years and combined Schoute's analytical methods with Boole Stott's unusual ability to visualize the fourth dimension. After Schoute's death in 1913 Boole Stott was isolated from the mathematical community until about 1930, when she was introduced to the geometer H.S.M. Coxeter, with whom she collaborated until her death in 1940.

Samenvatting

Alicia Boole Stott was een Ierse die belangrijke bijdragen heeft geleverd aan de vier-dimensionale meetkunde. Hoewel ze nooit wiskunde studeerde, leerde ze zichzelf om de vierde dimensie te "zien". Dit bijzondere mentale vermogen stelde haar instaat om een nieuwe methode te ontwikkelen voor het visualiseren van vier-dimensionale polytopen. In het bijzonder construeerde ze doorsneden van deze vier-dimensionale objecten met een drie-dimensionale ruimte. De zo verkregen reeks archimedische veelvlakken presenteerde ze in de vorm van tekeningen, bouwplaten en drie-dimensionale modellen. Het opduiken van een uitgebreide verzameling van deze afbeeldingen en modellen in de Rijksuniversiteit Groningen (RuG) is te verklaren uit de samenwerking tussen Boole Stott en de Groningse meetkundehoogleraar P.H. Schoute. De samenwerking duurde meer dan 20 jaar, en stoelde op de analytische methoden van Schoute in combinatie met het ongewone visualisatievermogen van Boole Stott. Na het overlijden van Schoute (1913) verleende de RuG Boole Stott in 1914 een eredoctoraat. Ze bleef buiten de wiskundige gemeenschap, tot ze rond 1930 in contact kwam met de meetkundige H.S.M. Coxeter, met wie ze tot haar dood in 1940 samenwerkte.

1. Introduction

In the spring of 2001 an old paper roll containing drawings of polyhedra was found in the basement of the Mathematics, Astronomy and Physics building at the Zernike Campus of the University of Groningen. The drawings, carefully made and beautifully colored, looked like a series of related Archimedean solids, first increasing and then

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decreasing in size. The roll was unsigned, but the drawings were quickly recognized to be representations of three-dimensional models held at the Groningen University Museum and known to be the work of Alicia Boole Stott (1860–1940), the daughter of the logician George Boole (1815–1864). Further investigation revealed that Boole Stott had enjoyed a fruitful collaboration with the Groningen professor of geometry, Pieter Hendrik Schoute (1846–1913), for over twenty years,[1] and had been awarded an honorary doctorate by the University of Groningen in 1914. In this paper we trace the history of Boole Stott's drawings and models, beginning with a biography of Boole Stott. We set Boole Stott's work into its historical context with a short account of the early history of four-dimensional geometry. It is clear that Boole Stott developed a mental capacity to understand the fourth dimension in a way that differed considerably from the analytic approach of other geometers of the time, in particular that of Schoute. But how did she come to develop such an understanding of four-dimensional geometry? Before describing Boole Stott's work we consider this question and discuss the origins of Boole Stott's interest in polytopes.

2. A special education

Alicia Boole Stott was born in Castle Road, near Cork (Ireland), on June 8th, 1860 [MacHale, 1985, Chapter 17].[2] She was the third daughter of the logician George Boole and his wife Mary Everest (1832–1916). George Boole died from fever at the age of 49 in 1864, leaving his widow and five daughters with very little money. With an insecure future in Ireland, Mary Boole moved to London, taking Alicia's four sisters with her. Alicia meanwhile stayed in Cork with her maternal grandmother and a great uncle. At the age of eleven she moved to London to live with her mother and sisters where she remained for seven years. Her stay in London was interrupted by one visit to Cork in 1876, where she worked in a children's hospital for a short period [Coxeter, 1987, 221].

As a woman born in the middle of the 19th century, Alicia had little educational opportunity. In England, colleges did not offer degrees to women and the study of science or mathematics was not encouraged. Alicia was only four years old when her father died so she had little opportunity to be influenced by him, and as a child, her acquaintance with formal mathematics consisted only of the first two books of Euclid [Coxeter, 1948, 292–293]. Nevertheless, she was well taught by her mother.

Mary Everest Boole had studied mathematics with her husband, both before and after her marriage, and she retained an interest in the subject throughout her life [Michalowicz, 1996].[3] When she moved to London after Boole's death she took a job as a librarian at Queen's College in Harley Street, a college for the higher education of women.[4] But her passion was for teaching, and she liked giving advice to the students. She had innovative ideas about education, believing, for example, that children should manipulate objects in order to make the unconscious understanding of mathematical ideas grow. Her belief that models should be used to visualize and understand geometrical objects is reflected in the following passages taken from her writings on pedagogy:

> The use of the single sewing cards is to provide children in the kindergarten with the means of finding out the exact nature of the relation between one dimension and two. (...) There is another set of models,[5] the use of which is to provide people who have left school with a means of learning the relation between three dimensions and four. [Everest Boole, 1909, 21]

> The geometric education may begin as soon as the child's hands can grasp objects. Let him have, among his toys, the five regular solids and a cut cone. [Everest Boole, 1904, 110]

Mary Everest Boole wrote several books on different aspects of pedagogy, most of which were published several years after they were written [Everest Boole, 1931]. Many of the matters on which she wrote (the occult, eastern philosophy, evolution and animal rights) were considered controversial at the time which is why her work took so long to be recognized [Michalowicz, 1996, 294–295]. Thus, although the two works cited above were not published

[1] The *Dictionary of Scientific Biography* erroneously gives Schoute's date of death as 1923 [Struik, 1975].

[2] MacHale [1985] is the main source for biographical information on Alicia Boole Stott.

[3] For further information on Mary Everest Boole see Cobham [1951].

[4] Queen's College, which was founded in 1848, was the first college of higher education for women in England. For a history of the College, see Kaye [1972].

[5] Everest Boole did not include a description of this set of models.