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Emmy Noether

Figure 1: An image of Emmy Noether, (© Creative Commons)

Emmy Noether (1882-1935)

Emmy Noether also contributed significantly to the development of mathematics and is known as the 'mother of modern algebra'. Noether (1882-1935) was brought up in a middle-class German-Jewish family and was part of a famous group of Jewish intellectuals who fled Nazi Germany.[1] It was not until after she finished her teaching qualification that she became interested in mathematics and algebra. This interest led Noether to be accepted as one of only two women who were allowed to audit mathematics courses at the University of Erlangen. From 1904, the University officially allowed women to register, which allowed Noether to become an enrolled student. She went on to receive her doctorate with a dissertation on invariants of ternary biquadratic forms.[2] In 1915, Noether was called to Göttingen to assist David Hilbert in his study of general relativity. Hilbert arranged for Noether to teach courses under his name as women were not allowed to teach or earn a salary at this time.

[1] D. E. Rowe, *Emmy Noether – Mathematician Extraordinaire*, (Springer Nature, 2021), p.10.
[2] V. J. Katz, *A History of Mathematics*, (Pearson, 2014), p. 900.

Noether's work between 1907-1919 consisted mainly of algebraic invariant theory, Galois Theory and Physics.[3] She proved two foundational theorems for elementary particle physics and general relativity. The main theorem she published, known as Noether's Theorem, states that: symmetry under translation corresponds to conservation of linear momentum, symmetry under rotation corresponds to conservation of angular momentum and symmetry in time corresponds to conservation of angular momentum.[4] Noether placed great emphasis on the structural aspects of algebra as a pose to the computational aspects of algebra and suggested creating a whole new field of study Algebraic Topology.[5]

She also wrote the Noetherian ring; a ring R is called a Noetherian ring if for all ascending chains of proper ideals embedding, say:

$$I_1 < I_2 < I_3 < \cdots \text{ (for all } j \text{ in the natural numbers, } I_j \text{ are all ideals for R).}$$

There is a positive integer n such that $I_n = I_{n+1}$. This condition is called the Ascending Chain condition, which laid the foundations for Noether's work on factor sets and normalisation. Similar to Lovelace in computing, Noether's work in algebra had a profound impact on the development of mathematical knowledge in the 19th and 20th century.

These examples highlight that despite the long history of elitism that has engulfed this discipline, numerous brilliant women have made significant contributions to its growth.

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[3] D. Radford, *On Emmy Noether and Her Algebraic Work* (2016), All student Thesis, paper 75, Governors' State University, p. 13.

[4] Ibid., p. 13.

[5] V. J. Katz, *A History of Mathematics*, (Pearson, 2014), p. 900.