The Disconnect Between Undergraduate Standard Mathematics and Modern Applied Mathematics: A Review of Integral Transform Research

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Keywords: Applied mathematics, Information processing, Fourier analysis, Laplace Transform

Recent concerns highlight a shortage of engineering graduates to meet modern demands, in part due to the high drop-out rates in undergraduate engineering programs (Faulkner et al., 2019; Flegg et al., 2012). Various studies have attributed this to engineering students' struggles to transfer mathematical knowledge to engineering contexts (Ekici et al., 2020; Harris et al., 2015). This concern is further highlighted by Chui and Jiang (2013), who described a recent shift in modern applied mathematics from modeling through differential equations to information processing and data science, requiring a different set of mathematical concepts which have not been emphasized in the past, such as Fourier analysis and abstract linear algebra. This literature review aims to study the disconnect between the standard mathematics curriculum and modern applied mathematics. Due to the breadth of existing research, this review focuses on integral transforms (Laplace and Fourier Transforms), which provide a bridge between the standard mathematics curriculum and modern applied mathematics. The following two research questions guide the review: How are the Laplace and Fourier Transforms viewed differently between mathematicians and engineers? Is the standard mathematics curriculum effective in preparing engineers for their future studies, particularly in the field of Fourier analysis?

Methods

A literature search of mathematics education and engineering education journal articles and conference proceedings was performed with the keywords "Engineering Mathematics Education" and "Applied Mathematics Education". Articles not explicitly addressing differential equations, Fourier analysis, Fourier Transforms, or Laplace Transforms were excluded. A total of 57 articles were found, primarily in the *International Journal of Research in Undergraduate Mathematics Education*, *International Journal of Mathematics Education in Science and Technology*, and *IEEE Transactions on Education*. Open coding was performed on the 57 articles where key words and ideas along with specific excerpts were extracted. Themes and connections within the literature relating to the research questions were then identified.

Preliminary Findings

Integral transforms are viewed differently between mathematics and engineering due to the primary generating question, or question motivating integral transform use, in these contents. In mathematics, transform methods are a tool to solve differential equations. In engineering, transform methods are the key to characterizing and analyzing linear systems without finding closed-form solutions (Rønning, 2021; Rezvanifard and Radmehr, 2024). This results in key tasks, techniques, justifications, and theories involving the information processing dimension of mathematics, including complex numbers, functional analysis thinking, and the frequency domain, being underdeveloped in undergraduate mathematics courses (Ekici et al., 2020; Hochmuth & Peters, 2021). During the poster session, I plan to share findings and implications of this review. I also plan to obtain feedback regarding future directions and questions the RUME community would like explored regarding modern applied mathematics education.

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