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The Role of Mathematics
In Engineering practice and in the formation of Engineers

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In Ireland, the number of school leavers pursuing professional engineering careers has been declining almost continuously over twenty years. Students wishing to pursue professional engineering degree courses are required to demonstrate proficiency in secondary school mathematics at the higher level. Yet, only a 16% minority of secondary school mathematics students in Ireland takes the Leaving Certificate mathematics exam at the higher level. It is widely thought that mathematics is the "key academic hurdle" in producing a supply of engineering graduates [1].

While mathematics has been regarded as a fundamental knowledge area underpinning engineering practice there is a belief among some practising engineers that the mathematics they learned is not applicable to their work [2]. Advances in technology, knowledge diffusion and almost instant information access, support the view that teaching "engineers to think analytically will be more important than helping them memorise algebra theorems" [3]. However, research concerning the type of mathematics used by engineers in their work is sparse [2,4].

This research was inspired by the observation that there is a lacuna in the literature concerning the nature of mathematics' role, if any, as a significant cause of the declining number of students entering professional engineering education courses. Additionally there is currently no broad picture of the mathematical expertise required or used by practising engineers. This study investigates (i) the role of mathematics in engineering practice and (ii) whether there is a relationship between students' experiences with school mathematics and their choice of engineering as a career.

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The population of interest in this study is professional engineers practising in Ireland. A sequential explanatory mixed methods design, where the subsequent collection and analysis of interview data builds on the analysis of survey findings, is employed. Practising engineers' mathematics usage is considered in three parts, namely *curriculum mathematics, mathematical thinking*, and motivation to take a mathematical approach. *Curriculum mathematics* usage is measured by a derivation of de Lange's mathematics assessment pyramid [5]. *Mathematical thinking* usage relates to mathematical modes of thinking used in work. Motivation to take a mathematical approach concerns the affective domain whereby it is believed that attitudes, beliefs, values and emotions play a central role in mathematics learning [6]. Engineers' experiences of school mathematics and the impact of their feelings about mathematics on their choice of engineering careers are also investigated.

The findings show that (i) engineers' feelings about mathematics are a major influence on their choice of engineering as a career; (ii) teachers, affective factors and sociocultural influences are the main contributors to engineers' interest in and learning of mathematics; (iii) while almost two thirds of engineers use high level *curriculum mathematics* in engineering practice, mathematical thinking has a greater relevance to engineers' work compared to *curriculum mathematics;* (iv) professional engineers' *curriculum mathematics* usage is dependent on the interaction of engineering discipline and engineering role, their *mathematical thinking* usage is independent of engineering discipline and engineering role; (v) engineers show high affective engagement with mathematics and their usage of mathematics in engineering practice is influenced by the value given to mathematics within their organisation; and (vi) the focus on "objective" solutions at the expense of tacit knowledge in mathematics education reduces the value of mathematics in engineering practice. ■

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