INITIAL RESULTS FROM A SURVEY OF ENGINEERS: FROM NOT USING MATHEMATICS AT ALL, TO PERFORMING TASKS USING SOFTWARE. IMPLICATIONS FOR RESEARCH

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The mathematical training of engineers and their practical application of mathematics have received increased attention from researchers over the past 15 years. In this paper, we present results from the pilot phase of a survey that will eventually be distributed to a large sample of engineers. Drawing on elements of the Anthropological Theory of the Didactic (ATD), we focus on tasks in which mathematics is explicitly or implicitly involved, and on the ways participants complete these tasks. Drawing on responses from ten engineers, we find that three report not needing any university mathematics in their professional practice. Seven carry out tasks that implicitly involve mathematics and seven carry out tasks (albeit infrequently) in which the use of mathematics is explicit. All participants use software to perform these tasks.

INTRODUCTION AND RESEARCH PROBLEM

The role of mathematics in engineering programmes has been the subject of debate since the beginning of the 20th century, before the creation of the International Commission on Mathematical Instruction (ICMI) in 1908 (Howson et al., 1986). At that time, differences between the ways mathematicians and engineers approach mathematics had already been identified (Snyder, 1912). However, it is only in the last 25 years that there has been a significant amount of research on these issues. One of the pioneering works at the beginning of the 2000s (Kent & Noss, 2003; Noss, 2002) produced striking results: although structural engineers report having taken several university mathematics courses, they do not " 'use mathematics' of any sophistication in their professional careers" (Noss, 2002, p. 54), and "calculus […] may rarely feature explicitly for many engineers" (Kent & Noss, 2003, p. 17).

These results sparked a renewed interest in the mathematical training of engineers, and the topic was explored in the Second Handbook of Research on Mathematics Teaching and Learning (Artigue et al., 2007). In particular, the high dropout rates in engineering programmes were linked to students' difficulties in mathematics courses (Artigue et al., 2007; Biza et al., 2022; Faulkner et al., 2025), and the need to understand the situation became urgent. Since then, a variety of studies have addressed the mathematical training of engineers; however, many studies did not question for years the content of mathematics courses (Artigue, 2016), focusing instead on knowledge use and transfer: *can students use mathematical content to solve a specific applied problem in their field?* In the last 15 years, some researchers have taken a different

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approach, studying professional practices to better understand engineers' needs and how they use mathematics (Biza et al., 2022). This has revealed, for instance, that although integrals underlie several notions in engineering, certain practices related to these notions (bending moments and electric potential) do not draw on the tasks, techniques, or rationales learned in mathematics courses (González-Martín, 2021).

It has been reported that most studies related to the mathematical training and practices of engineers are small-scale studies (Faulkner et al., 2025). The largest study to date was conducted by Quéré (2017, 2019), in which 261 French engineers completed an online survey. Only 24% of respondents reported that their university mathematical training was well adapted to their current professional needs, while 52% stated that it was poorly adapted. Only 129 participants (49% of the sample) reported a need for mathematics in their professional activities, while just 43% of these (21% of the sample) reported needing calculus. A need for simple scientific calculations was reported by 33% of the sample, and the most cited mathematical domain was statistics (30% of the sample). These results were enlightening, as they relativised the mathematical needs of a large sample of engineers working in different branches of engineering. However, while the sample was large, the survey omitted certain questions that could help determine how engineers use mathematics, such as "*for those who use calculus, what content is used and how?*" or "*for those who use simple calculations, what mathematical content is used and what is it used for?*"

Building on Quéré's survey, we aim to better understand the specific content used in engineers' professional practices and the tasks that leverage this content by posing the following research question: *What mathematical content is most frequently reported as being necessary across several branches of engineering, and for which tasks?* The findings could help inform broader discussions about the mathematical training and needs of engineers. We are currently testing our survey, and this paper presents data from ten participants, revealing patterns that warrant further investigation.

THEORETICAL FRAMEWORK

Our study investigates professional practices in engineering, focusing on tasks that involve mathematics and identifying the mathematical notions required to perform them. We rely on the Anthropological Theory of the Didactic (ATD, Bosch et al., 2020), which postulates that knowledge is transformed by the *institutions* that produce and use it, a phenomenon known as *transposition*. Therefore, mathematical knowledge may undergo transpositive effects when it is used in different institutions. For example, the notion of 'derivative' has a specific meaning in a calculus course and is used to solve certain tasks; however, this notion may be presented differently in an engineering course, where it is used to solve completely different tasks. ATD sees institutions in a broad sense, as social systems that legitimise specific practices which draw on a particular body of knowledge. Accordingly, our study adopts a macrolevel perspective, where *mathematics* and *engineering* are two different institutions.

The transposition of knowledge and how it 'lives' in specific institutions are modelled using the construct of *praxeology*. ATD posits that knowledge has two components: the *praxis* (practical block) and the *logos* (theoretical block). In particular, the *praxis* comprises tasks (or types of tasks) and techniques used to solve them. The *logos* block comprises a rationale (the technological discourse) that explains and justifies the techniques, and a theory that serves to justify the rationale.

We note that this stage of our study focuses primarily on identifying tasks and some general elements of the associated techniques. We seek to determine which tasks are common across different branches of engineering, as well as the mathematical content that forms the basis of the technique mobilised to accomplish these tasks.

METHODS

Our study draws on Quéré's (2017, 2019) survey, although it goes further with respect to the type of information collected. Our online survey was designed to collect the following data: 1) the participants' profile (sex, age, current profession); 2) their training (educational institution, year of graduation, branch of engineering); 3) the mathematical training provided in their university programme (course type, course content, relevance to their current profession); 4) mathematical needs in the workplace (the mathematical content used, tasks where this content is used, the frequency of these tasks, whether and how this content was presented in their degree, practical ways of addressing the tasks, etc.).

The survey is hosted on the Université de Montréal's LimeSurvey platform, which allows for the storing of data on our own servers. As we are currently at the testing and validation phase, we asked two engineers (one in Canada, one in France) to distribute the survey within their circle. We received ten anonymous responses. The participants' profiles are presented in Figure 1. We received six responses from engineers trained in France and four from engineers trained in Canada, working in seven different engineering disciplines (including three industrial engineers and two civil engineers). All participants have experience working in positions related to engineering.

Figure 1: Profile of the ten participants in the pilot phase of our study.

Participant	Country where diploma was obtained	Year	Speciality
F1	France	1999	Automation engineering
F2	France	1974	Materials and metallurgical engineering
F3	France	2013	General engineering
F4	France	1998	Industrial engineering
F5	France	2013	Building engineering
F6	France	2015	Mechanical engineering
C1	Canada	2023	Civil engineering
C2	Canada	1991	Civil engineering
C3	Canada	2024	Industrial engineering
C4	Canada	1989	Industrial engineering

Given the small sample size, we are currently pursuing a qualitative analysis of the data collected. We first identified the reported mathematical needs. Then, we identified

the reported tasks, as well as the associated mathematical content and how each task is typically performed (by hand, using software, etc.). We used open coding (Saldaña, 2013) to identify and group the types of tasks reported by participants, as well as the mathematical domain necessary to solve these tasks. The initial data analysis was conducted by the first author and later verified independently by the other authors, with minor disagreements resolved.

RESULTS

Participants were asked to rate how well the content of their mathematical courses serves their current professional needs. We observe a divergence in participants' perceptions (Figure 2), which echoes the results reported by Quéré (2019). Surprisingly, even participants working in the same branch of engineering differ in their views.

Figure 2: The participants' view of their mathematical training.

Very poorly adapted (1)	**Poorly adapted (2)**	**Neutral (3)**	**Well adapted (4)**	Very well adapted (5)	Average: 3.5 Median: 4
-	Two: F1, F4	Two: F5, C1	Five: F2, F6, C2, C3, C4	One: F3	

For the participants who rate their mathematical training as poorly adapted to their needs, their justifications are as follows:

F1: I don't use mathematics.

F4: Aside from occasional, very basic trigonometry calculations, I've never needed to use mathematics in my profession.

Among the participants who are more satisfied with their mathematical training, some report needing it only occasionally, or are critical of it:

F3: No need to delve deeper into everyday work. Advanced mathematics is used occasionally. There's no need to go beyond the material covered in preparatory classes/engineering courses.

F6: Generally suitable, but often too theoretical for an engineer's needs. Most of the practical applications seen in physics or engineering sciences are the most relevant.

Only seven participants report using mathematics in their profession: F2, F5, F6, C1, C2, C3, and C4. Paradoxically, although F3 is very satisfied with their mathematical training, they report not needing mathematics in their profession, although they identify mathematical content that they implicitly use on occasion (Figure 4). This includes pre-university content, such as trigonometry, simple functions, or algebraic manipulations, which eight other participants also report using in their jobs. As for the participants' application of university content, we observe greater variability. For instance, only five use content related to calculus (F2, F3, F6, C1, C2) or descriptive statistics (F2, F3, C1, C3, C4), four use content related to linear algebra (F3, C1, C2, C3) or probability (F3, C1, C3, C4), three use content related to numerical methods (F3, C1, C3) or discrete mathematics (F3, C3, C4), two use content related to inferential statistics (F3,

C4) and none uses content related to differential equations or group theory. With respect to calculus, we observe that half of the participants report using it, which is more than twice the proportion in Quéré's (2019) sample (21%). This calls for further investigation into which branches of engineering use calculus more frequently. In this sense, we observe certain trends among our participants: the three participants specialising in industrial engineering (F4, C3, C4) report not needing content from calculus, while the two participants working in civil engineering (C1, C2) report that they do. Given that calculus courses are a major factor in engineering dropout rates (Faulkner et al., 2025), and since only half of our participants report needing this content, further inquiry is warranted into the role of calculus courses in preparing engineers across all branches of engineering.

Figure 3 presents the participants' most frequently performed professional tasks that require the explicit use of mathematics. C1 appears to be the participant who explicitly uses mathematics most often, although we note their use of software in performing the task. C2, who works in the same branch of engineering, reports significantly different needs. This may be explained by their job description: while C1's work involves advanced structural engineering, C2 works with transmission lines. It is therefore important to consider that engineers with the same specialisation can occupy very different jobs. The other participants rarely perform their most frequent task requiring the explicit use of mathematics (every two weeks, or once per month or less), generally representing less than 5% of their weekly workload. We also note that all participants use software to perform their task, with five eschewing specialised software and using simpler Office applications.

Figure 3: Participants' most frequent tasks requiring the explicit use of mathematics

	Task	Mathematical need	Implementation of technique	Frequency	Percentage of weekly workload	Mathematical content
F2	Mean standard deviation.	Understanding basic statistical tools, characteristics of sampling, bias, differentiation of populations.	A significant portion by hand, use of Office.	Once per month or less.	Between 5% and 20%.	Descriptive statistics, inferential statistics.
F5	Calculating the linear length of a staircase based on the size of the stairwell, the number of floors, and the height of each floor.	Determining the quantity of a given element based on the building's characteristics. This is just one example; the task could also involve calculating the surface area of a roof based on its slope.	Use of Office.	Once per month or less.	Less than 5%.	Pre-university content.
F6	Selecting and sizing equipment/ components.	Estimating stresses/forces on certain components (e.g., from the operating pressure of a conduit, the required force of a cylinder, the reduction ratio of a system).	A significant portion by hand, use of Office.	Every two weeks.	Less than 5%.	Pre-university content, calculus.
C1	Calculating the section/inertia moduli of column/beam sections.	Elementary algebra. Requires familiarity with complex equations with several variables that change according to a multitude of factors.	Engineering software, use of Office, referral to specific books.	Almost every day.	Between 20% and 40%.	Pre-university content, calculus.
C2	Performing statistical calculations.	Calculating averages, standard deviations, etc.	Mathematical software.	Once per month or less.	Less than 5%.	Descriptive statistics.
C3	Revenue sharing among stakeholders.	Basic calculations (averages, etc.) and methods such as the Shapley Value.	Use of Office.	Every two weeks.	Between 20% and 40%.	Pre-university content, descriptive statistics.

C4	Data analysis, graphic representation	Basic statistics: mean, median, quartile	Use of Office.	Once per month or less	Less than 5%	Descriptive statistics.

We now turn to tasks involving mathematics performed without the conscious application of university course content. Seven participants report performing such tasks (Figure 4). Their responses show that they most often perform tasks in which the use of mathematics is implicit (they can be completed without consciously applying university mathematical content). Again, we observe differences within specialisations: C1 and C2 (both working in civil engineering) perform different tasks using mathematics implicitly, and while F4 performs tasks in which mathematics is implicit, C3 and C4 do not (all three work in industrial engineering). Interestingly, most participants report performing these tasks by making estimates mentally. This might indicate that a conceptual understanding of the mathematics involved is more important than the application of content per se. This could also be true for the tasks involving an explicit use of mathematics: since all participants report using software, it is possible that the conceptual aspects of the mathematics involved are more important than the algorithmic elements. Further study of these activities may lead to ideas for recommendations to improve mathematics courses in engineering programmes.

Figure 4: Participants' most frequently performed tasks requiring the implicit use of mathematics.

	Task	**Implementation of technique**	**Frequency**	**Percentage of the weekly workload**
F2	When a solution is not found, using reasoning by contradiction.	Much of the task does not require precise calculations; instead, the participant makes estimates (mentally).	Every two weeks.	Between 5% and 20%.
F3	Testing ultrasound / sonographic methods.	Much of the task does not require precise calculations, instead, the participant makes estimates (mentally); a significant portion by hand; use of Office; use of online resources.	Two or three times per week.	Between 5% and 20%.
F4	Calculating distance, speed, and acceleration.	Much of the task does not require precise calculations, instead, the participant makes estimates (mentally); a significant portion by hand; use of Office.	Once per month or less.	Less than 5%.
F5	Assembling sales sheets.	Use of Office.	Every two weeks.	Between 5% and 20%.
F6	Failure analysis.	Much of the task does not require precise calculations, instead, the participant makes estimates (mentally); a significant portion by hand.	Once per week.	Between 5% and 20%.
C1	Programming.	Use of Office.	Once per week.	Between 5% and 20%.
C2	Engineering and preparation of maintenance work.	Much of the task does not require precise calculations, instead, the participant makes estimates (mentally).	Two or three times per week.	Between 5% and 20%.

We conclude this section with some additional information: Only one participant (C4) reports having had to learn new mathematical content (inferential statistics) for their job, while another (F2) indicates that they outsource certain tasks requiring the use of mathematics to an external consultant; these tasks involve analysing probability, calculating multiple correlations, or solving differential or finite element equations.

FINAL REMARKS

The findings presented in this paper are the result of our study's pilot phase, involving the testing and validation of a survey that we plan to distribute among a large number

of engineers trained in different countries. Setting aside statistical validity, the data collected in this first phase nevertheless provides interesting information that warrants further investigation. We believe our current findings contribute to the literature and to the discussion concerning the mathematical training and needs of engineers.

Our findings align with and build on results obtained by Quéré (2017, 2019). First, there is variability in our participants' perception of their university mathematical training. The findings that some engineers do not use any university mathematics in their profession are consistent with previous research results (Kent & Noss, 2003; Noss, 2002; Quéré, 2017, 2019). This pattern was observed across a significant proportion of respondents—approximately half of Quéré's (2019) participants and about one third (three out of ten) in our small sample. Additionally, 90% of our respondents report using pre-university content; however, the application of *university* content varies widely. Further study could lead to recommendations for the reorganisation of mathematical course content in engineering programmes (as has already occurred at some universities), and a reassessment of calculus as the 'gatekeeper' course in engineering programmes (Biza et al., 2022; Faulkner et al., 2025). We are also interested in analysing similarities and differences in how university mathematical content is applied within and across different branches of engineering.

This first stage of our study identifies which mathematical domain is more frequently used by respondents (for instance, descriptive statistics and pre-university content). The next stages of our study will allow us to identify specific content. We also observe that all our participants use software to perform tasks requiring mathematics. Considering the number of tasks in which mathematics is implicit, and given the widespread use of software, our study's next phase will focus on engineers' integration of mathematical knowledge and computational skills, as well as their need to leverage their conceptual understanding of mathematics.

The results of this first stage call for a more comprehensive, quantitative investigation of mathematical needs in engineering, while still considering qualitative aspects. The second stage will seek to identify which content is used most often in different branches of engineering, whether certain tasks are performed more frequently within or across branches, how often these tasks occur, and the extent to which software is used. In a third stage, we will conduct interviews with participants to further examine their techniques and identify their actual use of mathematics. We hope our results will contribute to the international debate on the mathematical training of engineers, and that they will eventually be helpful to decision-makers seeking to reduce dropout rates in engineering programmes.

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