MATHEMATICS LEARNING BELIEFS OF FIRST-YEAR ENGINEERING STUDENTS

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ABSTRACT

Students' beliefs about mathematics influence their learning behaviour and, potentially, achievement. This investigation surveyed two large classes of first-year engineering students on entry to university and at the end of their first-year mathematics module. One class began their degree programme in academic year 2018/19 and the other, whose secondary education was disrupted by the covid-19 pandemic, started university in 2023/24. The students had a strong appreciation of the value of mathematics to their studies and career and a strong acceptance of struggle; these beliefs strengthened over the module. Beliefs associated with a growth mindset were dominant and student confidence was generally high. However, the 2023/24 class was less assured than the 2018/19 class. Some increase in confidence was observed over the year for the latter group, this being more noticeable for the students of higher ability, but there was little change in confidence for the 2023/24 class. Females believed more strongly in the value of mathematics and seemed more strongly to enjoy trying to solve new problems. Self-efficacy was relatively high and increased over the year. It is suggested that the teaching and learning methods – weekly practice, frequent opportunities for peer review, inclusion of problems with engineering applications – had a positive impact on students' beliefs.

KEYWORDS

mathematics, learning beliefs, self-efficacy, first-year engineering students, pandemic, Standards: 8, 11.

INTRODUCTION

Beliefs and attitudes towards mathematics, including enjoyment, confidence and value, seem to be positively associated with achievement in mathematics at secondary level (Wen & Dubé, 2022). Self-reinforcing cycles have been observed, with success in mathematics leading to better attitudes and increased confidence, resulting in greater persistence and further success. Conversely, failure in mathematics can lead to negative attitudes and lower confidence, resulting in reduced effort and further failure (Ernest, 2003). Beliefs and attitudes can be distinguished – beliefs are formed based on the information available and they lead to attitudes, from which intentions and then behaviours may result (Fishbein & Ajzen, 1975; Parsons, 2014). Note that mathematics anxiety, being an emotional factor, is not considered under the heading of beliefs and attitudes towards mathematics.

Resilience is a desirable attribute in general. It is the quality of being able to respond positively in the face of difficulties (Kooken *et al*., 2016). Mathematical resilience is a term that describes both the process of becoming positioned to deal with difficulties that arise when learning mathematics and the outcome of adapting successfully to those difficulties or challenges. Mathematically resilient learners have the self-efficacy, flexibility, motivation and perseverance needed to overcome difficulties (Lee & Johnston-Wilder, 2024). Mathematical resilience encompasses a collection of attitudes and behaviours that can be divided into four categories – growth mindset, struggle, value and support.

A growth theory of learning mathematics refers to the belief that people can improve their mathematical abilities through application and instruction (Dweck, 2008). Having a growth mindset should facilitate perseverance when confronted with challenges. In contrast, those with a fixed mindset may regard difficulties as an indication that they have reached the limit of their understanding. Struggle refers to the belief that sometimes much effort is required because mathematics can be a challenge to learn – not because of personal incompetence or limitations. In theory, students who understand that struggling with mathematics is not unusual should have more tolerance and stronger staying power in the face of difficulties (Kooken *et al*., 2016). Value refers to the extent to which students find studying mathematics important in attaining their goals (Kooken *et al*., 2016). When learning and achievement associated with a subject is valued, students will become more willing to engage actively with it (Deci *et al*., 1991).

Mathematics confidence is associated with an expectation of attaining good results, assurance of ability to handle difficulties, feeling good about mathematics as a subject, and lacking nervousness or worries about learning mathematics (Galbraith & Haines, 1998; Pierce *et al*., 2007). Self-efficacy relates to confidence to perform a specific task. This can be considered a belief regarding whether the mathematical task can be performed successfully (Parsons, 2014). Evidence shows significant relationships between confidence and achievement (Parsons, 2014) and that confidence promotes positive cycles of further effort and achievement (Parsons *et al*., 2011).

Given the connection between beliefs and behaviour, and potentially achievement (Pierce *et al*., 2007), it is of interest to investigate students' beliefs regarding mathematics as they begin their undergraduate studies. The following research questions have been proposed:

- What beliefs do first-year engineering students hold about learning mathematics?
- How do their beliefs change over the first year of their degree programme?
- What differences in beliefs were evident between students beginning their degree programme before and after the covid-19 pandemic?

The paper describes the subjects of the investigation, the learning environment and the research instrument. It presents the findings of the research under categories of value, struggle, growth, confidence and self-efficacy. An explanation for the results is offered along with implications for student persistence.

METHODOLOGY

Background

The author is module coordinator and lecturer for Mathematics 1, a core module (20 CATS points) for first-year aerospace, mechanical and product design engineering students in Queen's University Belfast. Students are not permitted to proceed in their degree without passing this first-year mathematics module within two attempts. The first half of the syllabus is mainly a repetition of secondary-level topics (logarithms, polynomial equations, partial fractions, trigonometry, complex numbers, differentiation and integration) while the second half has newer topics (including matrices, differential equations, vectors, Laplace transforms and descriptive statistics). Teaching takes place over 25 weeks with a two-hour lecture and one-hour feedback session per week. A formal teaching style is generally employed in lectures with effort made to present the material in a logical manner. Numerous worked examples are included to help reinforce the material being taught while typical engineering applications illustrate the usefulness of mathematics to engineers.

The class size has ranged 155 – 195 since 2016. Most have come through the UK A-level system with 52% having at least grade A in A-level Mathematics during the period 2016-2020; this proportion has increased to 75% during 2022-2025. On average, 7% of the A-level students have completed Further Mathematics. Entrance requirements for aerospace, mechanical and product design engineering students in our university were identical during the period of this research.

Subjects

Two groups of first-year aerospace, mechanical and product design engineering students enrolled in Mathematics 1 were involved in this study – those who began their degree programme in academic year 2018/19 and those who began in 2023/24.

Questionnaire design

The research instrument was a questionnaire, designed for our particular setting (Pierce *et al*., 2007) but based on the literature. The questionnaire contained 23 items. The first three items were used to collect biographical information – the students' secondary-level qualification in mathematics, whether they achieved an A-level in Further Mathematics, and gender. The remaining 20 items (Table 1) were used to assess students' beliefs towards learning mathematics. Items 1 – 15 were developed from the literature (Kooken *et al*., 2016; Fogarty *et al*., 2001) and are related to factors associated with mathematical resilience and to confidence. In Table 1, these are categorised as value (V), struggle (S), growth (G) and confidence (C). Responses were invited on a scale: strongly agree, agree, neither agree nor disagree, disagree, strongly disagree. Items 16 – 20 were used to measure self-efficacy (SE); as recommended (Bandura, 1997; Nielsen & Moore, 2003), their content is specific and relates to topics relevant to engineering mathematics. Responses were invited on this scale: highly certain can do, certain can do, moderately certain can do, could make an attempt, cannot do at all.

Table 1. Items on the mathematics learning beliefs questionnaire

item number	item	category
1	Maths will be useful to me in my life's work.	V1
2	Having a solid knowledge of maths helps me understand more complex topics in my field of study.	V2
3	Maths develops good thinking skills that are necessary to succeed in any career.	V3
4	Good mathematicians experience difficulties when solving problems.	S1
5	Everyone makes mistakes at times when doing maths.	S2
6	Struggle is a normal part of working on maths.	S3
7	Maths can be learned by anyone.	G1
8	If someone is not good at maths, there is nothing that can be done to change that.	G2
9	People are either good at maths or they aren't.	G3
10	I have less trouble learning maths than other subjects.	C1
11	When I have difficulties with maths, I know I can handle them.	C2
12	I have a mathematical mind.	C3
13	I enjoy trying to solve new mathematical problems.	C4
14	I find maths frightening.	C5
15	I find maths confusing.	C6
16	Rate your capability to rearrange equations and formulae.	SE1
17	Rate your capability to resolve a fraction into its partial fractions.	SE2
18	Rate your capability to differentiate products and quotients.	SE3
19	Rate your capability to integrate by parts or by substitution.	SE4
20	Rate your capability to solve first-order differential equations by separating the variables.	SE5

Procedure

The questionnaires were conducted using electronic systems but at an in-person class led by the author. In the 2018/19 year, the questionnaire was first introduced at the beginning of the first class of Mathematics 1. This was at 9.05 am on the students' second day of their degree programme. The lecturer explained the purpose of the research and administered the survey, deliberately before introducing the module, so that students' responses would not be influenced by thoughts about the mathematics they were about to undertake. The questionnaire was hosted on SurveyMonkey and students responded using an electronic device, typically a smartphone. The questionnaire was repeated (identical content and same administrative procedure) at a mathematics lecture in week 23 to measure students' beliefs at the end of the teaching phase of the module. By this stage, students had completed a significant amount of formative, continuous assessment (a weekly worksheet, peer review and reflection) but summative assessment (submission of log book and final examination) had not yet taken place (Cole & Fraser, 2025). In 2023/24, the process was repeated with the same questionnaire being distributed at the beginning of the week 1 lecture and in week 23. The only change was that Microsoft Forms replaced SurveyMonkey as the survey platform.

Completion of the questionnaires was voluntary (although encouraged) and anonymous. Mean time taken to complete them was two and a half minutes (week 1 questionnaires) or two minutes (week 23 questionnaires).

RESULTS

Table 2 shows the biographical data of the two populations. Response rates to the survey were high in week 1 (84% and 86% in 2018/19 and 2023/24 respectively); a high attendance at the first class of a new module would be expected. The response rates in week 23 were lower (57% and 73% in 2018/19 and 2023/24 respectively); lecture attendance tends to decline over the year so lower figures are to be expected. Response rates in week 23 were lower for males than for females (56% v 61% in 2018/19, 70% v 79% in 2023/24). Considering the larger sub-groups according to secondary mathematics qualification, response rates in week 23 were lower for those with lower grades (for example, 88%, 70%, 44% for A-level grade A*, A and B students respectively in 2018/19).

Note that A-level is a subject-specific qualification taken in the UK typically by school students aged 16 – 18. Leaving certificate is the equivalent award in the Republic of Ireland. In Table 2, “other (UK)” represents UK students with alternative qualifications to A-levels (for example, vocational). “International” refers to students from outside the UK and Republic of Ireland.

Table 2. Number of students participating in research study

		number of students	response rate (%)	gender		secondary qualification in mathematics						
				male	female	A-level grade A*	A-level grade A	A-level grade B	A-level grade C	other (UK)	Leaving Cert	inter-national
2018/19	class size	160		127	33	16	57	57	1	10	8	11
	week 1	134	84	107	27	16	49	48	1	7	8	5
	week 23	91	57	71	20	14	40	25	0	4	7	1
2023/24	class size	160		121	39	30	73	34	0	2	17	4
	week 1	138	86	102	36	30	60	28	0	2	16	2
	week 23	116	73	85	31	25	57	19	0	1	13	1

Table 3 presents responses to the items related to value, struggle, growth and confidence (items 1 – 15) for the two classes in week 1. A red – white colour scale is used to highlight responses of large magnitude. In both years, there was generally strong agreement as to the value of mathematics in studies and work. Across the questionnaire in each year, the strongest agreement for any item was for item 1. There was strong agreement that struggle is a normal experience when working on mathematics. This feeling was stronger for the 2023/24 class. Responses under the category of growth showed greater variation, with a large proportion of neutral responses for items 7 and 9. However, the distribution of responses had a similar profile in both years. While most agreed that mathematics can be learned by anyone, neutral responses or disagreement represented 25% or 29% of the class in the two years. A small proportion agreed and many were neutral (27% or 28% in the two years) that people were either good at mathematics or not. However, in both years, there was strong disagreement with the statement that nothing could be done for those considered not good at mathematics.

Many of the responses to the confidence items were neutral although, in general, they indicated that high levels of confidence existed. This was true regarding being able to handle difficulties, having less trouble with mathematics than other subjects, and enjoying solving new problems. While responses to items 10 – 13 showed a similar profile in 2018/19 and 2023/24 on entry to university, responses to items 14 and 15 showed differences. A large proportion of both classes disagreed that they found mathematics frightening but this disagreement was stronger in 2018/19. While most students (55%) in 2018/19 disagreed that they found mathematics confusing, many were neutral (39%). However, in 2023/24, there was a much higher agreement with the sentiment (20%) and only 41% disagreeing that they found mathematics to be confusing.

Table 3. Measures of agreement to items related to value, struggle, growth and confidence. A red – white scale is used where red indicates a high magnitude and white indicates zero.

			value			struggle			growth			confidence					
			Maths will be useful to me in my life's work.	Having a solid knowledge of maths helps me understand more complex topics in my field of study.	Maths develops good thinking skills that are necessary to succeed in any career.	Good mathematicians experience difficulties when solving problems.	Everyone makes mistakes at times when doing maths.	Struggle is a normal part of working on maths.	Maths can be learned by anyone.	If someone is not good at maths, there is nothing that can be done to change that.	People are either good at maths or they aren't.	I have less trouble learning maths than other subjects.	When I have difficulties with maths, I know I can handle them.	I have a mathematical mind.	I enjoy trying to solve new mathematical problems.	I find maths frightening.	I find maths confusing.
		item number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
		% strongly agree	65.4	61.7	54.1	32.6	57.1	30.1	28.6	1.5	0.8	23.5	12.2	19.8	21.4	0.8	0.8
		% agree	33.8	36.1	39.1	46.2	40.6	60.2	42.9	1.5	12.8	49.2	61.1	66.4	61.8	5.3	4.5
2018/19	week 1	% neutral	0.8	2.3	4.5	12.1	1.5	7.5	17.3	9.0	27.8	23.5	23.7	12.2	13.0	18.2	39.4
		% disagree	0.0	0.0	2.3	6.8	0.8	2.3	11.3	57.1	45.1	3.8	3.1	1.5	3.8	60.6	47.0
		% strongly disagree	0.0	0.0	0.0	2.3	0.0	0.0	0.0	30.8	13.5	0.0	0.0	0.0	0.0	15.2	8.3
		% strongly agree	63.8	51.4	37.0	39.1	61.6	47.1	20.3	0.0	0.0	21.7	9.4	22.5	21.0	0.7	1.4
		% agree	34.1	47.8	52.9	44.9	37.0	45.7	55.1	2.9	9.4	53.6	63.8	56.5	57.2	10.9	18.8
2023/24	week 1	% neutral	2.2	0.7	5.8	7.2	0.7	6.5	15.9	9.4	26.8	14.5	19.6	18.8	18.8	23.9	39.1
		% disagree	0.0	0.0	4.3	8.7	0.7	0.7	7.2	60.1	50.0	8.7	6.5	2.2	2.9	49.3	37.7
		% strongly disagree	0.0	0.0	0.0	0.0	0.0	0.0	1.4	27.5	13.8	1.4	0.7	0.0	0.0	15.2	2.9

Table 4 shows percentage point differences between male and female responses to the items related to value, struggle, growth and confidence (items 1 – 15) for the two classes in week 1. In both years, females were more strongly convinced of the value of mathematics, especially regarding its use in life's work. Different beliefs were also evident in the category of struggle, however, the profiles were different in the two years. In 2018/19, males more strongly believed that struggle was normal and that everyone makes mistakes when working at mathematics, whereas in 2023/24 females more strongly agreed with these statements. In 2018/19, there was slightly stronger agreement from males that mathematics can be learned by anyone, but females held this belief more strongly in 2023/24. Differences between male and female beliefs under the category of confidence were less obvious, however, females in both years more strongly enjoyed tackling new problems. In 2018/19, males disagreed more strongly that they found mathematics confusing, but responses to this item in 2023/24 showed little dependence on gender.

Table 4. Percentage point differences between males and females in levels of agreement to items related to value, struggle, growth and confidence. Red indicates a higher value for females, blue indicates a higher value for males, and white indicates no difference.

			value			struggle			growth			confidence					
			Maths will be useful to me in my life's work.	Having a solid knowledge of maths helps me understand more complex topics in my field of study.	Maths develops good thinking skills that are necessary to succeed in any career.	Good mathematicians experience difficulties when solving problems.	Everyone makes mistakes at times when doing maths.	Struggle is a normal part of working on maths.	Maths can be learned by anyone.	If someone is not good at maths, there is nothing that can be done to change that.	People are either good at maths or they aren't.	I have less trouble learning maths than other subjects.	When I have difficulties with maths, I know I can handle them.	I have a mathematical mind.	I enjoy trying to solve new mathematical problems.	I find maths frightening.	I find maths confusing.
		item number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
		% strongly agree	-20.2	-10.9	-6.4	8.4	15.9	14.5	8.0	-2.8	-3.7	-4.3	-4.0	-4.0	-21.3	-3.8	0.9
		% agree	19.2	8.1	-2.1	-16.4	-18.8	-17.5	2.7	1.9	2.1	-0.9	9.0	-8.3	19.6	1.8	-8.7
2018/19	week 1	% neutral	0.9	2.8	5.7	-3.4	1.9	4.8	-10.8	-7.3	-11.6	5.3	0.7	10.4	-3.0	-1.3	-3.6
		% disagree	0.0	0.0	2.8	8.6	0.9	-1.8	0.2	2.0	5.5	-0.1	-5.8	1.9	4.8	8.4	15.4
		% strongly disagree	0.0	0.0	0.0	2.9	0.0	0.0	0.0	6.1	7.7	0.0	0.0	0.0	0.0	-5.1	-4.0
		% strongly agree	-19.0	-9.3	-6.4	-10.9	-18.1	-15.2	-10.1	0.0	0.0	-0.7	-2.3	0.3	2.1	1.0	2.0
		% agree	19.8	8.3	0.2	4.4	19.9	9.2	-0.7	0.2	1.5	-10.1	-0.2	1.3	-9.0	-4.1	2.9
2023/24	week 1	% neutral	-0.8	1.0	4.1	2.3	-2.8	8.8	2.8	9.0	-16.3	0.8	3.9	-4.6	6.7	9.8	4.1
		% disagree	0.0	0.0	2.1	4.2	1.0	-2.8	6.0	-5.1	7.5	8.0	1.3	2.9	0.2	-4.7	-5.4
		% strongly disagree	0.0	0.0	0.0	0.0	0.0	0.0	2.0	-4.1	7.4	2.0	-2.8	0.0	0.0	-2.0	-3.6

Table 5 presents a comparison of beliefs at the beginning and end of the teaching phase of the module for both classes. Given that beliefs showed some variation with secondary-level mathematics grade, and given that response rates to the questionnaires varied according to that secondary-level grade, table 5 is restricted to students with A-level Mathematics grade A. Including the whole class would mean a different profile of students in the weeks 1 and 23 responses and would therefore invalidate the comparison.

Table 5. Measures of agreement to items related to value, struggle, growth and confidence for students with A-level Mathematics grade A. A red – white colour scale is used where red indicates a high magnitude and white indicates zero.

			value			struggle			growth			confidence					
			Maths will be useful to me in my life's work.	Having a solid knowledge of maths helps me understand more complex topics in my field of study.	Maths develops good thinking skills that are necessary to succeed in any career.	Good mathematicians experience difficulties when solving problems.	Everyone makes mistakes at times when doing maths.	Struggle is a normal part of working on maths.	Maths can be learned by anyone.	If someone is not good at maths, there is nothing that can be done to change that.	People are either good at maths or they aren't.	I have less trouble learning maths than other subjects.	When I have difficulties with maths, I know I can handle them.	I have a mathematical mind.	I enjoy trying to solve new mathematical problems.	I find maths frightening.	I find maths confusing.
		item number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
2018/19	week 1	% strongly agree	67.3	57.1	55.1	39.6	57.1	34.7	24.5	0.0	0.0	18.8	12.5	22.9	17.0	0.0	2.1
		% agree	32.7	42.9	36.7	39.6	40.8	59.2	49.0	2.0	18.4	56.3	64.6	66.7	61.7	4.2	4.2
		% neutral	0.0	0.0	6.1	14.6	0.0	6.1	16.3	8.2	22.4	22.9	20.8	10.4	17.0	12.5	31.3
		% disagree	0.0	0.0	2.0	6.3	2.0	0.0	10.2	61.2	44.9	2.1	2.1	0.0	4.3	66.7	52.1
		% strongly disagree	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.6	14.3	0.0	0.0	0.0	0.0	16.7	10.4
	week 23	% strongly agree	85.0	80.0	57.5	52.5	70.0	30.0	27.5	0.0	0.0	38.5	12.5	20.0	15.0	2.5	2.5
		% agree	12.5	20.0	42.5	40.0	27.5	57.5	47.5	2.5	10.0	51.3	67.5	70.0	52.5	10.0	2.5
		% neutral	2.5	0.0	0.0	5.0	0.0	10.0	15.0	7.5	32.5	10.3	17.5	10.0	22.5	10.0	25.0
		% disagree	0.0	0.0	0.0	2.5	2.5	2.5	7.5	67.5	40.0	0.0	2.5	0.0	5.0	62.5	60.0
		% strongly disagree	0.0	0.0	0.0	0.0	0.0	0.0	2.5	22.5	17.5	0.0	0.0	0.0	5.0	15.0	10.0
2023/24	week 1	% strongly agree	75.0	55.0	38.3	40.0	61.7	46.7	16.7	0.0	0.0	11.7	8.3	25.0	15.0	0.0	0.0
		% agree	23.3	45.0	50.0	43.3	36.7	50.0	58.3	1.7	6.7	65.0	70.0	56.7	61.7	8.3	16.7
		% neutral	1.7	0.0	10.0	10.0	1.7	1.7	18.3	10.0	26.7	11.7	18.3	16.7	23.3	28.3	45.0
		% disagree	0.0	0.0	1.7	6.7	0.0	1.7	5.0	56.7	53.3	11.7	1.7	1.7	0.0	48.3	35.0
		% strongly disagree	0.0	0.0	0.0	0.0	0.0	0.0	1.7	31.7	13.3	0.0	1.7	0.0	0.0	15.0	3.3
	week 23	% strongly agree	70.2	52.6	45.6	52.6	64.9	49.1	21.1	0.0	0.0	22.8	19.3	24.6	15.8	0.0	1.8
		% agree	29.8	47.4	45.6	42.1	33.3	43.9	52.6	0.0	21.1	50.9	56.1	57.9	54.4	10.5	22.8
		% neutral	0.0	0.0	5.3	5.3	1.8	7.0	15.8	14.0	29.8	14.0	12.3	17.5	22.8	19.3	29.8
		% disagree	0.0	0.0	1.8	0.0	0.0	0.0	10.5	70.2	35.1	8.8	10.5	0.0	7.0	50.9	38.6
		% strongly disagree	0.0	0.0	1.8	0.0	0.0	0.0	0.0	15.8	14.0	3.5	1.8	0.0	0.0	19.3	7.0

While students in both years were convinced of the value of mathematics at the beginning of their university career, that belief had strengthened by the end of the year, especially for the 2018/19 class. Under struggle, responses to item 4 showed notable changes over the year – both classes agreeing more strongly that good mathematicians experience difficulties when solving problems. For the 2018/19 class, beliefs regarding growth showed little change over the year. However, for the 2023/24 class, disagreement with the statement that people are either good at mathematics or they aren't had weakened by week 23, yet there remained strong disagreement with the suggestion that nothing could be done for those not good at mathematics. In 2023/24, beliefs regarding confidence showed little change by week 23. In 2018/19, by the end of the teaching phase, enjoyment in solving problems had declined slightly but students felt more comfortable learning mathematics compared to other subjects.

Self-efficacy was examined through items 16 – 20 which referred to fundamental procedures in engineering mathematics. These topics are all on the secondary-level curriculum (in the UK) but are reinforced during the first-year module in university. Students entering university in 2023/24 were a lot less confident in their abilities compared to those entering in 2018/19. This was particularly noticeable regarding calculus operations, especially integration and solving differential equations, and, to a lesser extent, regarding rearranging equations and formulae. In both years, students were much more confident in their abilities by week 23.

DISCUSSION

The mathematics learning beliefs questionnaire can be used to identify students whose beliefs may lead to a lack of persistence in mathematics (Kooken *et al.*, 2016). Students at the start of their degree programmes agreed particularly strongly with items associated with value indicating that they already had a strong appreciation of the importance of mathematics to their studies and career. This is important as students can then be expected to engage willingly and actively with the subject (Deci *et al.*, 1991). The results also showed a strong acceptance of struggle; this was especially the case for the 2023/24 students whose secondary education had been disrupted during the covid-19 pandemic. This is also encouraging since students who understand that struggle is inherent in the study of mathematics, even for experts, will be more tolerant and persistent when facing difficulties (Kooken *et al*., 2016). Beliefs associated with a growth mindset were dominant across both classes and there was strong rejection of the notion that nothing can be done for those deemed not good at mathematics. A growth mindset is a valuable asset at the beginning of university as it should help perseverance.

Student confidence was generally high in both classes although there were some interesting differences between them. The 2023/24 class, while mainly disagreeing that mathematics was frightening, were less assured than their 2018/19 counterparts. Similarly, the modal response regarding whether mathematics was confusing was neutral in 2023/24 whereas the 2018/19 class mainly disagreed. This might be further evidence of an impact of the covid-19 pandemic on students' beliefs about mathematics. The 2023/24 class would have been approaching the end of their fourth year in secondary school when the pandemic was declared in March 2020. Students in the UK take the General Certificate of Secondary Education (GCSE) qualification during their fourth and fifth years of secondary school (aged 15 and 16). Assessment is mainly by examinations. Therefore, the class beginning university in 2023/24 would have experienced, over the course of the pandemic, online teaching, studying more independent of teachers, absence of the final GCSE examinations in summer 2021, and adjustments in the assessment at A-level in 2021/22. This substantial disruption at a crucial stage of their education may have influenced feelings of confusion and fright towards mathematics, although it is important to note that these views were held by only a small minority within the class.

Females more strongly believed in the value of mathematics to their work and understanding compared to males. Gender differences in responses regarding struggle were inconsistent over the two classes. Differences in male and female confidence were slight, although females seemed more strongly to enjoy trying to solve new problems. The results regarding confidence do not obviously concur with the established view that secondary-school girls have lower confidence in their mathematical ability than boys of the same age (Raabe & Block, 2024).

Some changes were evident over the teaching phase of the module. Students' appreciation of value increased, as did their belief that good mathematicians experience difficulties (struggle). For the 2023/24 class, there was little change in confidence over the year. Some increase in confidence was observed in 2018/19 and this was more prominent for the students of higher ability (grade A* at A-level). These results contrast with those of Code *et al*. (2016) who observed declines across a range of categories (including confidence, persistence, mindset, interest) over an academic year for first-year students studying calculus. This was described as a move away from "expert-like orientations" to mathematics over the duration of the academic year. The authors speculated that this was related to the nature of first-year mathematics modules, with their emphasis on procedural repetition and solution of low-level, inauthentic problems. Code *et al*. (2016) advocated the development of mathematical thinking and more emphasis on deeper approaches to learning at undergraduate level. The findings of the current study therefore give encouragement that the teaching and learning methods, and including problems with engineering applications, had a positive impact on students' beliefs.

The self-efficacy ratings in week 1 depended on prior mathematical grade. While the 2023/24 students were generally less confident at the start, particularly in differentiation and integration, their level of confidence by the end of the teaching phase was largely similar to that of the 2018/19 class, although still lagging in integration. An exception concerned the A-level grade B students of 2023/24 who expressed confidence similar to that of the 2018/19 students in algebraic topics (rearranging equations, partial fractions) at the start of the module. It isn't clear whether this was justified or a misplaced overconfidence in abilities in these areas.

The relatively high levels of self-efficacy are important given the moderate, positive correlation between self-efficacy and performance noted elsewhere (Hackett & Betz, 1989). Moreover, significant positive correlations have been found between self-efficacy and attitudes towards mathematics, including confidence, usefulness of mathematics, and effectance motivation (Hackett & Betz, 1989). The improvements in self-efficacy reported over the duration of the module may be related to the weekly, structured practice, frequent opportunities for peer review, and maintaining positive feelings regarding value of mathematics in studies and career. Certainly the self-efficacy results will have been influenced by the context of the survey (module and stage of education) (Brennan & Hugo, 2017).

Further analysis is needed to investigate statistical significance. Other limitations include the questionnaire responses being anonymous; this precludes tracking individuals to examine changes in beliefs over time and correlation with performance. Relating beliefs to the teaching and assessment methods could be considered more deeply through interviews. Finally, it would be of interest to study how the results would differ for students from other disciplines.

CONCLUSIONS

The first-year engineering students showed beliefs associated with mathematical resilience. While confidence was generally high, the class whose secondary education was disrupted by the covid-19 pandemic was less assured than the 2018/19 class. Self-efficacy was relatively high and increased over the year. There is some evidence that the teaching and assessment methods had a positive impact on students' learning beliefs.

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BIOGRAPHICAL INFORMATION

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