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Surveying Post-Leaving Certificate Students To Investigate Their Level Of Mathematical Preparedness For Progression To Higher Education Stem Courses: A Pilot Process

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SURVEYING POST-LEAVING CERTIFICATE STUDENTS TO INVESTIGATE THEIR LEVEL OF MATHEMATICAL PREPAREDNESS FOR PROGRESSION TO HIGHER EDUCATION STEM COURSES: A PILOT PROCESS

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ABSTRACT

A student's level of mathematics as they begin degree courses in STEM disciplines has been recognised as a key indicator of their success. While much research has taken place into secondary school mathematics teaching, a comparatively under-researched area has been that of Further Education, which supplies a smaller proportion of degree courses' student intake. The vast majority of Further Education students seeking progression opportunities to such courses study one of three mathematics modules: 'Mathematics 5N1833', 'Maths for IT 5N18396', or 'Maths for STEM 5N0556'.

As part of the author's PhD research project on the mathematical preparedness of students at FE level hoping to progress to a STEM degree course, it is envisaged that a survey of FE students be collected at the end of the 2023/24 academic year as one part of a broader, mixed-methods approach. In the interim, a pilot survey using a convenience sampling method was distributed and collected in April 2023 and is the focus of this paper. 57 responses were collected as part of this pilot process, indicating significant differences between the three module groups.

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1. INTRODUCTION

1.1 Overview

A student's level of mathematics as they begin degree courses at Higher Education (HE) in the Science, Technology, Engineering, and Mathematics (STEM) disciplines has been recognised as a key indicator of their success in those courses. Much research has taken place into the teaching of mathematics at second level, and much work has gone into a reshaped Leaving Certificate (Irish final splecondary school exam) syllabus designed to better equip students to succeed at third level, with greater emphasis on applicable rather than procedural knowledge. A comparatively under-researched area has been Further Education (FE) which supplies a smaller proportion of HE's student intake. The vast majority of FE-to-HE progressions occur from Post Leaving Certificate (PLC) courses, the sector's biggest single course type. Over 842 PLC courses ran in 2018 with approximately 28,000 learners (SOLAS, 2019). This compares to 362,899 students in second level education and 185,474 students in full-time higher education (Education, 2020).

1.2 Progression from the Further Education Sector to Higher Education

PLC graduates have a high progression rate within the HE sector, suggesting high completion rates in years after their graduation from FE (SOLAS & Education, 2020). In the context that PLC learners generally have lower-than-average Leaving Certificate grades, retention figures at HE compare favourably with direct entrants from lower Leaving Certificate points brackets (McGuinness et al., 2018).

Given the focus of this research on STEM disciplines, it was decided to investigate the 2023 entry routes to HEIs in the areas of Science, Technology, Engineering, and Mathematics, with a particular focus on mathematics requirements. An analysis was carried out of the requirements for entry onto what can broadly be defined as a STEM degree course, showing that three mathematics modules are studied at FE for the purposes of progression to STEM degrees, namely 'Mathematics 5N1833', 'Maths for Information Technology 5N18396', and 'Maths for STEM 5N0556'.

1.3 Mathematics in the Further Education Sector

Students studying any of the three FE mathematics modules are expected to achieve proficiency in units similar to those taught in the secondary school system (i.e., number, algebra, functions, calculus, geometry, trigonometry, statistics, and probability). 'Maths for STEM 5N0556' was the last of these modules to be developed, with the context for its development mirroring that of similar changes to mathematics curriculums both nationally and internationally.

The introduction of the Project Maths curriculum on a phased basis since 2010 has brought about significant change in how mathematics is taught and assessed in the Irish second level school system (Prendergast et al., 2017). This has sought to change the focus more towards problem-solving skills and conceptual understanding than a purely procedural approach. A similar problem was also recognised in an FE context, where the existing modules were not deemed adequate for entry to STEM degree courses by universities. A collaborative process involving subject experts (from TU Dublin, TCD, and UCD among others) and various other administrative bodies saw the development of ‘Maths for STEM 5N0556’, a one-year PLC mathematics module designed to be accepted by HEIs as an alternative to the HC3/H4 grade in Leaving Certificate mathematics (Robinson et al., 2018). This module differed significantly from previously existing mathematics modules, as outlined in Table 1 (Curriculum Development Unit, 2018a, 2018b, 2018c).

Table 1: The differences between QQI Level 5 Maths modules, as per module descriptors published by the City of Dublin Education and Training Board (CDETB) (Curriculum Development Unit, 2018a, 2018b, 2018c)

Module Title	Maths for STEM	Mathematics	Maths for IT
Module Code	5N0556	5N1833	5N18396
Level 5 Major award credit value	30	15	15
Directed learning hours (for a standard term of 26 weeks)	150 (typically 6 per week)	75* (typically 3 per week)	75* (typically 3 per week)
Recommended self-directed (i.e. learner-led) hours	150	75*	75*
Qualification requirements for teachers	Degree with strong maths emphasis	No requirements stated	No requirements stated
Number of assessments	5	3	3
Percentage of final grade from proctored assessment	85 – 100%†	40%	40%
Number of specific learning outcomes (SLOs)	97	36	55

**Duration in hours specified by module descriptors as 150 to include both directed & self-directed learning.*
†Option of a 15% Statistics research project which, if not taken, must be replaced by proctored assessment. Also, mastery in the topics of Arithmetic and Algebra must be demonstrated with a mark of >80% in first proctored assessment.

1.4 A Pilot Survey

The author’s PhD research project on the mathematical preparedness of FE students for HE STEM degrees currently involves a plan for data collection by way of a survey of such students nationwide. However, given that this data collection would need to take place towards the end of any academic year, it was felt that there was insufficient time for the planning and execution of a process of this scale in the 2022/23 academic year. It was decided that this would take place in 2023/24 and, in the interim, a pilot survey on a smaller scale could be designed, collected, and analysed with a view to informing this larger process. This would utilise a convenience sampling technique made possible by the author’s own professional background and contact network as an FE teacher in Coláiste Dhúlaigh CFE.

2 METHODOLOGY

2.1 ‘Maths for STEM 5N0556’ Informing a Diagnostic Test of Key Skills

Including a diagnostic test of key mathematical skills in the pilot survey would allow for a comparative analysis of mathematical preparedness of the three cohorts under consideration. Tests of this sort have become a popular tool for measuring mathematical skills (Michael Carr et al., 2013; Carr et al., 2015; M. Carr et al., 2013; Faulkner et al., 2021; Lawson, 1997; Malcolm & McCoy, 2007) and have proven useful for profiling particular cohorts. If such a test were established at this point of the research, further comparison would then also be possible at a later point between these cohorts and the other intake streams for STEM degrees, the largest of which is school-leavers. This would help to give a sense of how FE students compare with others in terms of key mathematical skills upon entry to HE.

It was deemed important that any diagnostic test contained within the pilot survey would have an explicit relationship with the mathematical requirements of STEM degrees in HE in order to align with the central aim of the research, namely to measure the mathematical preparedness of FE students for such a progression. To that end (bearing in mind that the module was devised by subject experts for this specific purpose - see Section 1.3) questions on the diagnostic test were to be chosen using ‘Maths for STEM 5N0556’ as a guide. Its overall aim is described as “addressing the need for adequate mathematical preparation and attainment for FET award holders who wish to progress to STEM degree programmes” and the five components of mathematical proficiency it sets out to develop are conceptual understanding, strategic competence, procedural fluency, adaptive reasoning, and productive disposition (Curriculum Development Unit, 2018a).

The module’s indicative content sets out learning outcomes requiring specific skills to be mastered. While certain of these outcomes do require development of non-procedural skills (e.g., “*Explain the relationship between logical equivalences and set identities*”, “*Investigate the concept of the limit of a function*”, “*Engage in discussions about the purpose of probability*”) they for the most part require the development of procedural fluency skills. Given the constraint on the scope of the proposed diagnostic test imposed by a one-hour time limit (a standard FE class duration), it was decided to structure the initial skeleton of the test around procedural skills. Due consideration would then be given to ensure that all components for the development of mathematical proficiency listed above were also incorporated. Given the role ‘Maths for STEM 5N0556’ was taking in the construction of the diagnostic test, great care would also need be taken to ensure that respondents studying ‘Mathematics 5N1833’ and ‘Maths for IT 5N18396’ would not be at a disadvantage.

Three techniques for administering diagnostic tests are commonly used: computer-based tests, paper-based tests which are optically marked based on multiple-choice answer types, and paper-based tests which are marked by hand (Appleby et al., 1997). The benefits and limitations of each of these choices were considered and the decision was made to use a hand-marked, paper-based test, particularly in light of sample size issues foreseen in the pilot survey and the research more broadly.

2.2 Testing ‘Procedural Fluency’ Skills in the Diagnostic Test

Five units of the ‘Maths for STEM 5N0556’ module populated the ‘Procedural Fluency’ aspect of the diagnostic test. In order to ensure students would be able complete the test during a standard hourlong class, consideration was given to the number of questions which should be asked in this part of the test, bearing in mind that further material testing conceptual understanding, strategic competence, adaptive reasoning, and productive disposition would also have to be included at a later point. A diagnostic test conducted by Faulkner et al. (2021) on entrants to TU Dublin degrees contained 18 questions – 9 testing procedural skills and 9 testing problem-solving skills. This test was completed in 50-minute time slots. Considering this diagnostic test was to be aimed at a group of a broadly similar academic profile (i.e., FE and school-leavers upon completion of their studies vs new entrants to HE) and taking into account the requirement for supplemental questions beyond this stage, a skeleton of ten procedural fluency questions was deemed suitable, allowing for a simple overarching structure of two questions per unit as shown in Table 2.

Table 2: Distribution of Diagnostic Test Questions Across 'Maths for STEM 5N0556' Units

Unit	Number	Algebra	Functions & Calculus	Geometry & Trigonometry	Statistics & Probability
Question Number	1, 2	3, 4	5, 6	7, 8	9, 10

As stated in Section 2.1, respondents studying ‘Mathematics 5N1833’ and ‘Maths for IT 5N18396’ should not be at a disadvantage when completing the diagnostic test, given the role that the ‘Maths for STEM 5N0556’ module played in its construction. To that end, a detailed comparative analysis of the three modules’ indicative content would determine which specific skills to assess in the diagnostic test, such that it could be reasonably expected that all test items could be answered by a respondent studying any of the three modules. This comparison was to be carried out using thematic analysis, a technique outlined by Braun & Clarke (2006) which has been widely used in psychology but can and has also be used in a variety of fields that involve the analysis of qualitative data, including science education (Lemke, 1990). Thematic analysis involves the identification of patterns across datasets and is a technique in which the author’s own subjective experience is centrally important in interpreting meaning from data. Some examples of test items from the pilot survey following this process are shown in Table 3.

Table 3: Examples of Procedural Diagnostic Test Items

No.	**Question**	**Unit**
2	*Simplify $\log_{10}15+\log_{10}4-\log_{10}3$ to a single logarithmic term using the laws of logarithms.*	Number
7	*What is the equation of the line passing through the point (4,3) which is perpendicular to the line $y=2x+1$?*	Geometry & Trigonometry
10	*Two fair dice are rolled. What is the probability of getting two sixes?*	Statistics & Probability

2.3 Measuring the Productive Disposition of Respondents

Stage & Kloosterman (1992) developed an instrument called the Indiana Mathematical Belief (IMB) scales to interrogate students’ beliefs around mathematics and problem-solving. This instrument takes the form of a Likert scale questionnaire investigating five commonly held beliefs about mathematics, namely:

1. *I can solve time-consuming mathematics problems*
2. *There are word problems that cannot be solved with simple, step-by-step procedures*
3. *Understanding concepts is important in mathematics*
4. *Word problems are important in mathematics*
5. *Effort can increase mathematical ability*

These beliefs were chosen by Stage & Kloosterman “because they should help to explain motivation to learn to solve mathematical problems”, and because positive attitudes in these five areas were deemed key to the development of a student’s problem-solving skills. It was decided to include the instrument in the pilot survey as a measure of respondents’ productive disposition.

2.4 The Remaining 'Mathematics Proficiency' Components

The remaining components of mathematical proficiency to be tested were conceptual understanding, strategic competence, and adaptive reasoning (Curriculum Development Unit, 2018a). In order to integrate these components and reflect their importance, it was decided that the existing skeleton of the diagnostic test of mathematical skills would be expanded in scope using supplemental questions.

A summary of where these components have been tested is shown in Table 4.

Table 4: Summary of the Components of 'Mathematics Proficiency' Tested

'Mathematics Proficiency' Component	1: Number		2: Algebra		3: Functions & Calculus		4: Geometry & Trigonometry		5: Statistics & Probability	
	Q1a	**Q2a**	**Q3a**	**Q4a**	**Q5a**	**Q6a**	**Q7a**	**Q8a**	**Q9a**	**Q10a**
'Conceptual Understanding'		✓				✓			✓	
'Strategic Competence'	✓			✓			✓			
'Adaptive Reasoning'			✓		✓			✓		✓

Examples of test items for each of the three components are shown in Table 5, showing also the relationship to the procedural questions in Section 2.2.

Table 5: Examples of Non-Procedural Diagnostic Test Items

Component	**No.**	**Question**	**Unit**
Conceptual Understanding	2a	*Explain your understanding of a logarithmic term such as* $log_{10}1000$	Number
Strategic Competence	7a	*Justify your answer for the above question by plotting both lines on the coordinate plane below.*	Geometry & Trigonometry
Adaptive Reasoning	10a	*When using probabilities how confident should we be in any prediction made? For example, if the probability of flipping a coin and getting heads is ½, should we reasonably expect five heads results from ten coin-flips? What about 1,000 coin-flips? Discuss.*	Statistics & Probability

3 RESULTS

The classes surveyed using a convenience sampling method were studying at Coláiste Dhúlaigh CFE. Of the 57 responses, 16 were studying 'Mathematics 5N1833' (*Pre-University Science* and *Engineering Technology*), 26 were studying 'Maths for IT 5N183962' (*Computer Science 1A* and *1B* and *Computer Networking*) and 15 were studying 'Maths for STEM 5N0556' (*Preliminary Engineering*).

3.1 Diagnostic Test of Key Mathematical Skills

A one-way analysis of variance (ANOVA) was carried out to gauge whether differences existed in diagnostic test marks between the module groups. This and further analyses of sections investigating procedural fluency, strategic competence, conceptual understanding, and adaptive reasoning can be seen in Table 6.

Table 6: ANOVA Results for Diagnostic Test Marks Across the Three Module Groups.

Diagnostic Test Mark	Module	Mean	S.D.	F-value	P-value
Overall (/200)	Mathematics 5N1833	47.19	33.09	19.33	0.000
	Maths for IT 5N18396	49.42	31.32		
	Maths for STEM 5N0556	112.4	39.7		
Procedural Questions (/100)	Mathematics 5N1833	31.81	21.32	11.5	0.000
	Maths for IT 5N18396	32.77	21.15		
	Maths for STEM 5N0556	62.53	19.97		
Questions Testing Conceptual Understanding (/30)	Mathematics 5N1833	3.63	5.66	10.1	0.000
	Maths for IT 5N18396	5.19	6.27		
	Maths for STEM 5N0556	13.47	8.15		
Questions Testing Strategic Competence (/30)	Mathematics 5N1833	8.13	5.95	20.35	0.000
	Maths for IT 5N18396	7.69	6.7		
	Maths for STEM 5N0556	20.67	7.35		
Questions Testing Adaptive Reasoning (/40)	Mathematics 5N1833	3.63	4.9	16.73	0.000
	Maths for IT 5N18396	3.769	4.852		
	Maths for STEM 5N0556	15.73	10.79		

Statistically significant differences between groups were noted across the board in this analysis ($P < 0.0005$), with mean results for respondents studying 'Maths for STEM 5N0556' higher in each section than those studying both other modules.

3.2 Productive Disposition – 'Belief' Scales

In order to determine whether the instrument first introduced by Stage and Kloosterman (1992) could be used to measure respondents' productive disposition, reliability analyses for each of the five belief scales were carried out.

Table 7: Reliability Analysis of the five 'Belief' Scales

Scale	n	Mean	S.D.	Cronbach's α
1: Difficult Problems	57	21.105	4.300	0.7952
2: Steps	55	16.891	3.332	0.5613
3: Understanding	57	24.386	3.569	0.7585
4: Word Problems	55	17.455	3.387	0.4881
5: Effort	57	25.456	3.616	0.8076

The reliability coefficients align broadly with Stage and Kloosterman (1992) and subsequent studies (Mason, 2003; Prendergast et al., 2018) in that Scale 4 cannot be considered reliable with a Cronbach's Alpha measure of 0.49. Thus, the responses from this scale were not considered from this point.

With a Cronbach's Alpha measure of 0.56, Scale 2 should be considered only moderately reliable. Thus, caution will be applied when interpreting respondents' scores in this scale. The other three belief scales can be considered highly reliable, with Cronbach's Alpha measures of over 0.75.

To gauge whether differences existed in beliefs related to the three mathematics modules studied within the sample, a one-way analysis of variance (ANOVA) was carried out using the three modules studied as subject variables and marks in the four relevant belief scales as dependent variables.

Table 8: ANOVA Results for the four 'Belief' Scales Across the Three Module Groups

Scale	Module	Mean	S.D.	F-value	P-value
1: Difficult Problems	Mathematics 5N1833	20.125	2.849	3.77	0.029
	Maths for IT 5N18396	20.269	4.378		
	Maths for STEM 5N0556	23.6	4.69		
2: Steps	Mathematics 5N1833	17.813	3.146	3.26	0.046
	Maths for IT 5N18396	15.654	2.87		
	Maths for STEM 5N0556	17.867	3.833		
3: Understanding	Mathematics 5N1833	23.63	4.06	3.28	0.045
	Maths for IT 5N18396	23.731	3.341		
	Maths for STEM 5N0556	26.333	2.795		
5: Effort	Mathematics 5N1833	25.38	4.88	0.3	0.741
	Maths for IT 5N18396	25.154	2.588		
	Maths for STEM 5N0556	26.067	3.77		

Statistically significant differences in belief were found to exist for Scales 1 and 3 ($P < 0.05$). For Scale 1, respondents studying 'Maths for STEM 5N0556' returned a mean mark of 23.6, whereas those studying 'Mathematics 5N1833' and 'Maths for IT 5N18396' returned lower mean marks (20.1 and 20.3 respectively). Likewise, for Scale 3, respondents studying 'Maths for STEM 5N0556' returned a mean mark of 26.3, whereas those studying 'Mathematics 5N1833' and 'Maths for IT 5N18396' again returned lower mean marks (23.6 and 23.7 respectively).

There were also found to be statistically significant differences between the three module sub-groups ($P = 0.046$) in the Scale 2 responses. Here, the mean marks for 'Mathematics 5N1833' and 'Maths for STEM 5N0556' (17.8 and 17.9 respectively) were both higher than that of 'Maths for IT 5N18396' (15.7). There was no significant difference found between the mean values for the 'Maths for STEM 5N0556' and 'Mathematics 5N1833' sub-groups ($P = 0.966$). However, as mentioned earlier in this section, with a Cronbach's Alpha measure of internal consistency of only 0.56 for this scale, caution should be applied and it may be unwise to infer too much from this result. The results for Scale 5 indicated that while 'Maths for STEM 5N0556' sub-group had a higher average than the others, this was not a significant difference.

3.3 Correlation Between Diagnostic Test Performance and 'Beliefs'

Scatterplots were generated to attempt to ascertain whether a relationship existed between 'beliefs' around mathematics and achievement, as shown in Figure 1 below.

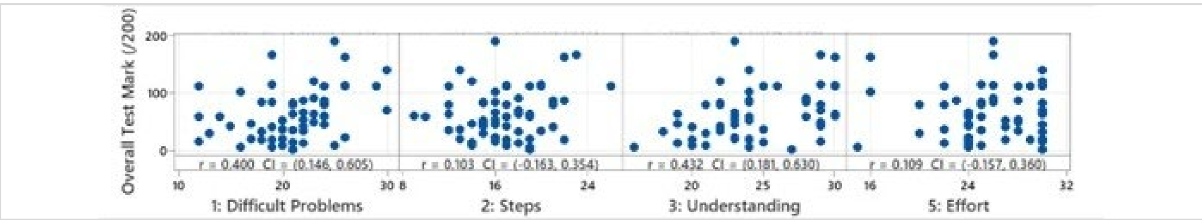

Figure 1: Correlation Plots of Overall Test Mark and the four 'Belief' Scales

Spearman correlation coefficients suggest moderate-to-strong positive correlations between both Scales 1 and 3 and the respondents' performance in the diagnostic test ($P < 0.005$, see Table 9). There was found to be negligible correlation between both Scales 2 and 5 and diagnostic test performance.

Table 9: Pairwise Spearman Correlations

Sample 1	Sample 2	N	Correlation	95% CI for ρ	P-Value
1: Difficult Problems	Overall Test Mark (/200)	57	0.400	(0.146, 0.605)	0.002
2: Steps	Overall Test Mark (/200)	57	0.103	(-0.163, 0.354)	0.448
3: Understanding	Overall Test Mark (/200)	57	0.432	(0.181, 0.630)	0.001
5: Effort	Overall Test Mark (/200)	57	0.109	(-0.157, 0.360)	0.422

A stepwise regression analysis was also carried out to select independent variables (in the form of 'Belief' Scales) which best predicted the response variable (diagnostic test performance). The order of entry to the model was determined by the Belief Scale which accounted for the most variance at each step, as shown in Table 10.

Table 10: Stepwise Selection of Terms (α to enter = 0.15, α to remove = 0.15)

	----Step 1----		-----Step 2----	
	Coef	**P-value**	**Coef**	**P-value**
Constant	-56.7		-101.6	
3: Understanding	5.00	0.002	4.24	0.006
1: Difficult Problems			3.01	0.018
S		40.4911		38.7744
R-sq		16.54%		24.86%
R-sq(adj)		15.02%		22.08%

Thus, the model determined that Scales 1 & 3 predicted test performance ($P < 0.05$).

3.4 Conclusions

The aim of the pilot survey, as discussed in Section 1.4, was to inform a larger data collection strategy for 2023/24. The results attained give an encouraging indication of how FE students' mathematical preparedness for progression to HE may be better understood. The differences between module groups in contact hours, learning outcomes, and assessments, as well as proctored assessments and teacher qualification requirements (see Table 1) appear to be reflected by significant differences across all of the five components of 'mathematics proficiency' deemed important for FE-to-HE progression. This could also have important implications for progression pathways in other countries with similarly structured education systems.

Any analysis of these results should be qualified by acknowledging the limitations of small sample size and strategy. It is reasonable to think that more reliable results and analysis would be achievable by surveying a broader, national cross-section of FE students in 2023/24. It is also envisaged that the structure and content of the diagnostic test be reconsidered by a subject expert panel from the HE and FE sectors in light of the results of this pilot process to bolster its validity.

REFERENCES

Appleby, J., Samuels, P., & Treasure-Jones, T. (1997). Diagnosys—A knowledge-based diagnostic test of basic mathematical skills. *Computers & Education*, *28*(2), 113-131.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Carr, M., Bowe, B., & Ní Fhloinn, E. (2013). Core skills assessment to improve mathematical competency. *European Journal of Engineering Education*, *38*(6), 608-619. https://doi.org/10.1080/03043797.2012.755500

Carr, M., Fidalgo, C., Bigotte de Almeida, M. E., Branco, J. R., Santos, V., Murphy, E., & Ní Fhloinn, E. (2015). Mathematics diagnostic testing in engineering: an international comparison between Ireland and Portugal. *European Journal of Engineering Education*, *40*(5), 546-556. https://doi.org/10.1080/03043797.2014.967182

Carr, M., Murphy, E., Bowe, B., & Fhloinn, E. N. (2013). Addressing continuing mathematical deficiencies with advanced mathematical diagnostic testing. *Teaching Mathematics and Its Applications: International Journal of the IMA*, *32*(2), 66-75. https://doi.org/10.1093/teamat/hrt006

Curriculum Development Unit, C. o. D. E. a. T. B. (2018a). Programme Descriptor Leading to 'Maths for STEM' Level 5 Award 5N0556. In.

Curriculum Development Unit, C. o. D. E. a. T. B. (2018b). Programme Module for 'Mathematics' Leading to Level 5 QQI Award 5N1833. In.

Curriculum Development Unit, C. o. D. E. a. T. B. (2018c). Programme Module for 'Maths for Information Technology' Leading to Level 5 QQI 5N18396. In.

Education, D. o. (2020). *Education Indicators for Ireland*. https://www.education.ie/en/Publications/Statistics/Key-Statistics/education-indicators-for-ireland-2020.pdf

Faulkner, F., Breen, C., Prendergast, M., & Carr, M. (2021). Profiling mathematical procedural and problem-solving skills of undergraduate students following a new mathematics curriculum. *International Journal of Mathematical Education in Science and Technology*, 1-30.

Lawson, D. (1997). What can we expect from A-level mathematics students? *Teaching Mathematics and Its Applications: An International Journal of the IMA*, *16*(4), 151-156.

Lemke, J. L. (1990). *Talking science: Language, learning, and values*. ERIC.

Malcolm, R. K., & McCoy, C. P. (2007). Evaluation of numeracy skills in first year pharmacy undergraduates 1999–2005. *Pharmacy Education*, *7*(1).

Mason, L. (2003). High school students' beliefs about maths, mathematical problem solving, and their achievement in maths: A cross-sectional study. *Educational psychology*, *23*(1), 73-85.

McGuinness, S., Bergin, A., Kelly, E., McCoy, S., Smyth, E., Watson, D., & Whelan, A. (2018). Evaluation of PLC Programme Provision. *ESRI Research Series*, *61*, 183.

McGuinness, S., Bergin, A., Kelly, E., McCoy, S., Smyth, E., Whelan, A., & Banks, J. (2014). Further education and training in Ireland: Past, present and future.

Prendergast, M., Breen, C., Bray, A., Faulkner, F., Carroll, B., Quinn, D., & Carr, M. (2018). Investigating secondary students beliefs about mathematical problem-solving. *International Journal of Mathematical Education in Science and Technology*, *49*(8), 1203-1218.

Prendergast, M., Faulkner, F., & Breen, C. (2017). *Mind the gap: an initial analysis of the transition of a second level curriculum reform to higher education. Teaching mathematics and its applications: an international journal of the IMA* (Vol. 36).

Robinson, P., Breen, C., O'Sullivan, C., Brannick, T., & Carr, M. (2018, 26th - 29th June 2018). *Widening Access to Engineering with Mathematics for STEM* The 19th SEFI Mathematics Working Group Seminar on Mathematics in Engineering Education, Coimbra, Portugal.

SOLAS. (2019). The 2019 Further Education and Training (FET) Services Plan. In (pp. 76).

SOLAS, & Education, D. o. F. a. H. (2020). Future FET: Transforming Learning, The National Further Education and Training (FET) Strategy 2020-24. In (pp. 72).

Stage, F. K., & Kloosterman, P. (1992). Measuring beliefs about mathematical problem solving. *School science and mathematics*, *92*(3), 109-115.