Report of the Irish Mathematical Society (IMS) on the NCCA Draft Specification for Leaving Certificate Mathematics at Higher and Ordinary Level

November 2026

The Irish Mathematical Society (IMS) is the national professional society representing the community of mathematicians based in Ireland, whose purpose is to promote and extend knowledge of mathematics and its applications.

> The Irish Mathematical Society recommends that the current curriculum review process for Mathematics at senior cycle be *paused*. Critical issues related to the draft curriculum need to be resolved: quality and coherence of content, bonus points, the AAC, the inappropriate format and template of the specifications, the lack of international benchmarking of content and standards, the under-preparation of students for further study, and the subsequent risk to STEM industries based on the reduction of mathematical knowledge and skills of post-primary students. The current draft, due to its poor quality, is not an appropriate starting point for any continuation of the review process. We call on the Minister for Education to pause the review process in order to safeguard post-primary mathematics education into the future.

The rationale for this recommendation is set out in this report. The recommendation is informed by detailed study of the draft specification, by consultation within the IMS including at its Annual General Meeting in August 2026, by participation of IMS members at the NCCA consultation events in Dublin and Athlone, by engagement with colleagues in the teaching profession, and by a survey of the views of 67 of our members across the higher education sector conducted in October 2026. The IMS view is also informed by many independent peer-reviewed research articles and government body reports.

Our primary arguments for a pause to the process are summarized here and detailed in subsequent sections.

1. *Context and Risks*
   Reducing mathematical content and rigour in Senior Cycle Mathematics poses serious risks to the competitiveness of Ireland's knowledge-based economy. Engineers Ireland and many others in

industry and beyond, have stressed this point. Over 93% of respondents to the IMS survey do not support the changes proposed in the draft curricula.

2. *Bonus Points*
   A thorough review is urgently needed of the effects of the 2012 introduction of bonus points for Higher Level Mathematics. While it has led to more than a doubling of numbers at Higher Level, there has been no increase in numbers progressing to STEM study and there is a documented decrease in the average and advanced levels of mathematics achievement in international tests. Any curriculum revision to Mathematics at Higher and Ordinary Levels should take place in the context of a decision on the future of bonus points.

3. *International Benchmarking*
   A review of practices and developments in comparable curricula internationally is a prerequisite for informed decision making about appropriate mathematical content and engagement expected of students. Engineers Ireland have called for this, as have circa 700 signatories to the `savemaths.ie` website drawn from industry, the tech sector, academia, the teaching profession and others. In the recent IMS survey almost 92% of respondents agreed with the need for benchmarking. The 1998 Education Act Section 41 (2) (d) mandates this benchmarking as a core responsibility of the NCCA, namely, "to advise the Minister on the standards of knowledge and skills... having regard to national and international standards". This prerequisite step must take place and must be fully discussed as part of the drafting process for the revised Leaving Certificate mathematics curricula.

4. *Preparation for further study in STEM Fields*
   The IMS does not believe that the revised content prepares students for third level. Our members teach on a wide range of third-level courses, including in mathematics, science, business, economics, finance, engineering, technology, education, humanities, social sciences and healthcare. 95% of respondents to the IMS survey believe that the proposed content of the Higher and Ordinary Level mathematics curricula will not adequately prepare students for study in Further and Higher Education.

5. *Lack of Coherence and of Specificity in the Draft*
   It is the view of the IMS that the current draft falls far short of the standards of consistency, specificity, precision and mathematical coherence that is required of a curriculum specification for the classroom and for assessment. The current draft is not in an appropriate form or format for a curriculum review process that adheres to disciplinary norms, provides sufficient detail to teachers and provides necessary clarity for students undertaking high-stakes assessments.

6. *The Alternative Assessment Component (AAC)*
   The IMS considers that the proposed AAC, concentrating mostly on Statistics and Data at the end of 5th year, is inappropriate for several reasons evidenced in further detail below. Regarding the AAC across all subjects, research highlighting likely disadvantage to some cohorts of students should be resolved in line with a "fairness imperative", as outlined by the State Examinations Commission in a 2018 report.

1 Introduction and Context

Mathematics is a foundational discipline that has facilitated the development of human understanding of the world around us across the fields of science, economics, technology, engineering and government[1]. Mathematics is an enabler of all advanced manufacturing and information technologies. Mathematical research, both fundamental and applied, underscores developments in cyber-security, LLMs, renewable energies and advances in our understandings of medicine, as well as supporting a knowledge-based economy[2]. A society that is mathematically literate underpins the foundations of democracy, where people can critically engage in topics related to their everyday lives[3]. Mathematics is therefore recognised internationally as a key focus of learning at all stages of education, and the mathematical achievement of children and young people plays a critical role in shaping both their academic and career trajectories[4].

In 1998, the Irish Council for Science, Technology and Innovation (ICSTI) published a report outlining how Ireland could become a knowledge-based society, emphasising continuous development of the primary and second level STEM curricula[5]. In 2025 multinational pharmaceuticals, medtech, and tech companies contributed 50.4% of value added in the Irish economy, enabled by a highly skilled workforce[6]. To support the continued development of a highly skilled workforce in Ireland the Expert Group on Future Skills Needs, a government body that advises on future skills requirements and associated labour market issues that impact on the national potential for enterprise and employment growth, has published three recent reports emphasising a need for more students to pursue STEM, further strengthening of STEM education in school and considerations of AI in the teaching and learning in STEM subjects[7,8,9]. In parallel, Ireland's STEM Education Policy (Department of Education and Skills, 2017) highlights mathematics as core to students' overall learning and, specifically, to underpinning STEM.

Students' experiences of mathematics at post-primary level, and particularly Senior Cycle, are highly influential in students' considerations of pursuing STEM beyond school, including further study of finance, technology (such as research in AI) and engineering[10]. Furthermore, given the rapid changes taking place in technology and industry, mathematics is ever more relevant to the education, progression and achievement of young people and in the development of critical thinking and problem solving skills. This is particularly pertinent given advances in Artificial Intelligence, requiring detailed conceptual knowledge

[1] Asare B., Arthur, Y.D., Obeng, B.A. (2026). A meta-analysis of the combined effect of self-efficacy and students' mathematics interest on mathematics achievement. Journal of Applied Research in Higher Education. https://doi.org/10.1108/JARHE-12-2025-1072

[2] Noyes, A. & Adkins, M. (2016). Studying advanced mathematics in England: findings from a survey of student choices and attitudes. Research in Mathematics Education, 18(3), 231–248. https://doi.org/10.1080/14794802.2016.1188139

[3] Schoenfeld, A., Brown, K., Moschkovich, J., Asturias, H., Martin, D. (2024). Civic reasoning and discourse across the curriculum: Mathematics. National Academy of Education and National Council of Teachers of Mathematics. https://files.eric.ed.gov/fulltext/ED672651.pdf

[4] Yolcu, A. (2019). Research on equitable mathematics teaching practices: Insights into its divergences and convergences. Review of Education, 7(3), 701–730

[5] ICSTI. (1998). Technology Foresight Ireland: An ICSTI Overview. https://enterprise.gov.ie/en/publications/publication-files/forf%C3%A1s/technology-foresight-ireland.pdf

[6] Central Statistics Office. (2026). Annual National Accounts 2025: Key Findings. Cork: Central Statistics Office. https://www.cso.ie/en/releasesandpublications/ep/p-ana/annualnationalaccounts2025/keyfindings/

[7] EGFSN (2022). AI Skills: A Preliminary Assessment of the Skills Needed for the Deployment, Management and Regulation of Artificial Intelligence. Expert Group on Future Skills Needs. https://enterprise.gov.ie/en/publications/publication-files/ai-skills.pdf

[8] EGFSN (2019). Forecasting the Future Demand for High-Level ICT Skills in Ireland, 2017–2022. Expert Group on Future Skills Needs. https://enterprise.gov.ie/en/publications/publication-files/forecasting-future-demand-high-level-ict\-skills-ireland-2017-2022.pdf

[9] EGFSN (2024). Skills for Biopharma. Expert Group on Future Skills Needs https://www.iua.ie/wp-content/uploads/2024/05/EGFSN-Biopharma-May-2024-Rev-2.pdf

[10] Berger, N., Fitzmaurice, O., Ryan, V., Mackenzie, E., Holmes, K. (2025). Secondary students' attitudes towards mathematics and science in Ireland: a latent profile analysis of TIMSS 2019 using situated expectancy-value theory. Irish Educational Studies, 1–23. https://doi.org/10.1080/03323315.2025.2549098

of linear algebra, statistics and programming.

While Ireland has rated well internationally in assessments, these results are declining. In PISA 2025, 15-year-olds in Ireland achieved a mean mathematics score of 480, which was significantly above both the OECD (463) and EU (460) averages and placed Ireland 14th of the 91 participating countries and economies (OECD, 2026). However, this represents a decline of 12 points since PISA 2022 (492) and of 24 points since PISA 2015 (504). Ireland's figures are particularly stark for the numbers of students who can be categorised as mathematically 'high achieving' in such international tests, representing only 6.1% of students in Ireland, below both the OECD (7.8%) and EU (6.7%) averages[11]. This represents a steady decline since 2012, when 11% of young people were in the high-achieving category[12]. These results suggests that Ireland's strong average performance is not matched by a correspondingly large group of students reaching the most advanced levels of mathematical literacy by age 15. Furthermore, research has demonstrated that students' problem solving skills have not improved since the previous curriculum reform in 2012, although there has been an improvement in procedural skills[13]. The cuts to subject topics and mathematically rigourous thinking proposed in the draft Ordinary and Higher Level curricula can only exacerbate this deficit.

Given the dependence of Ireland's economy on a scientifically educated workforce, these trends underline the risks posed to Ireland's competitiveness by a drastic contraction of both the breadth and depth of the Higher Level mathematics curriculum as proposed in the draft.

2 Bonus Points

The Bonus Points Initiative (hereafter referred to as bonus points) for higher level (HL) Leaving Cert Mathematics introduced in 2012, has achieved its objective of increasing the proportion of LC students opting to take HL to 30% by 2030. From 15.8% in 2011, this proportion reached 30% by 2017 and 36.3% in 2024. Research shows, however, that this initiative has had several serious unintended consequences, arguably nullifying the benefits of the increased HL participation to the point where serious re-examination of this policy now needs to happen.

Firstly, achievement at the top end of HL mathematics has seen a decline. In PISA 2025[14], in Ireland, and on average across the OECD and the EU, there has been a decline in the proportions of students performing at the highest levels. For Ireland, these changes were statistically significant compared to PISA 2015 and 2018. Engineers Ireland report concerns over already declined mathematics achievement levels for undergraduate students, that are significantly impacting third level experiences for students[15].

"Engineering educators already report having to support students who achieve well in Higher

[11] Karakolidis, A., Duggan, B., Keating, A., Toole, N. (2026). PISA 2025: Performance report for Ireland (ERC-2026-02). Educational Research Centre. https://doi.org/10.70092/1691815.0226

[12] O'Neill, B., Clerkin, A., Perkins, R., Soobrayen, K. (2026). Mathematics in context: students' attitudes towards mathematics and their experiences of the mathematics classroom in PISA 2022. Educational Research Centre. ERC-2026-01. https://doi.org/10.70092/1691813.0126

[13] Faulkner, F., Breen, C., Prendergast, M., Carr, M. (2023). Profiling mathematical procedural and problem-solving skills of undergraduate students following a new mathematics curriculum. International Journal of Mathematical Education in Science and Technology, 54(2), 220–249. https://doi.org/10.1080/0020739X.2021.1953625

[14] 1 PISA 2025: Performance report for Ireland https://doi.org/10.70092/1691815.0226

[15] Engineers Ireland (2026), https://www.engineersireland.ie/News/engineers-ireland-calls-for-review-\of-proposed-senior-cycle-maths-reform

> Level Mathematics in the Leaving Certificate but arrive at third level without sufficient mastery of some of the mathematical concepts required for engineering. This creates additional pressure for students and lecturers and can make an already demanding transition to third level more difficult."

Moreover, bonus points have caused a significant distortion effect on both the Ordinary Level (OL) and Higher Level cohorts[16]. A substantial proportion of teachers agree that many students are now only pursuing HL as a result of the bonus points initiative, and they persist with it despite experiencing considerable difficulties. The embedding of the initiative has dramatically altered the profile of both HL and OL cohorts and there is widespread reporting of resulting disruption to teaching and learning. Teachers report significant challenges in working with a wider range of achievement levels in the HL classroom, including increased time pressure to cover material and concerns about not reaching more challenging material. Worryingly, OL teachers report lower levels of achievement than prior to the introduction of bonus points.

The increased numbers of students taking HL mathematics is driven by the bonus 25 CAO points on offer[16]. This is understandable, since a pass grade or 40% at HL (a H6 grade) receives 46 plus 25 points, a total of 71 CAO points, compared to just 56 points for achieving 100% at OL. Even without bonus points, achieving 30% at HL (a H7 grade) yields 37 CAO points, the same awarded for obtaining 79% (O3 grade) at OL. This causes a strong extrinsic motivation for students to opt for Higher Level, regardless of their interest in or aptitude for the subject. This is clearly an unintended consequence of bonus points and, in and of itself, gives sufficient cause for an urgent review of the initiative from a policy perspective.

Finally, the bonus points initiative has not contributed as expected to STEM education outcomes (see also Engineers Ireland quote above). The STEM Education Policy Statement 2017–2026[17] set out to improve STEM education experience and outcomes:

> "In line with our ambition to have the best education and training service in Europe by 2026, Ireland will be internationally recognised as providing the highest quality STEM education experience for learners that nurtures curiosity, inquiry, problem-solving, creativity, ethical behaviour, confidence, and persistence, along with the excitement of collaborative innovation."

These improvements have not been realised. The Higher Education Authority reports that 29% of new entrants to higher education were studying STEM in 2011/12[18], before the introduction of bonus points. Recent HEA figures[19] put the proportion of first-time entrants studying STEM at 30% in 2021/22. This suggests no significant change in the proportion entering STEM, despite a more than doubling of those taking HL mathematics. Evidence suggests that, rather than enhancing the STEM education experience, bonus points may have hindered progress in this direction[16].

[16] Treacy, Prendergast, and O'Meara, N. (2025). Bonus Territory: The Shifting Landscape of Higher Level Senior Cycle Mathematics (2010–2024). Available at: https://epistem.ie/wp-content/uploads/2025/05/BPI-National-Report-Final-PDF.pdf

[17] Department of Education and Skills, 2017. STEM Education Policy Statement 2017–2026. Dublin: DES. Available at: https://www.education.ie/en/The-Education-System/STEM-Education-Policy/stem-education-policy-statement-2017-2026-.pdf

[18] Higher Education Authority, Higher Education System Performance: First Report 2014–2016. Dublin: Higher Education Authority, Appendix 2, p. 105.

[19] Higher Education Authority (2023). STEM in Higher Education in Ireland. Research Info-Byte Series. Published March 2023. Available at: https://hea.ie/statistics/data-for-download-and-visualisations/\research-info-byte-series/stem-in-higher-education

In summary, while the introduction of bonus points has certainly increased the numbers taking HL (40% in 2026) this has led to: no discernible differences in the numbers taking STEM in higher education, a decrease in the number of students achieving an advanced level of mathematics in international tests, and with no discernible improvements in students' problem-solving skills[20].

Bonus points are not working as intended and their downsides have now been recognized and documented[16]. On this basis, awarding bonus for higher level mathematics urgently needs to be re-assessed. This should have happened prior to the current curriculum review process. For this reason, that process should now be paused and only restarted after a full re-examination of the bonus points issue.

3 International Benchmarking

Benchmarking against international comparisons should have been a prerequisite for this curriculum review process, as it is mandated by the 1998 Education Act Section 41 (2) (d) governing the NCCA, namely, "to advise the Minister on the standards of knowledge and skills... having regard to national and international standards"[21].

While a few sample international jurisdictions are listed on the NCCA Background Paper, namely, Hong Kong, New Zealand, Singapore and the International Baccalaureate (IB) Programme, these were not discussed during the meetings of the NCCA's Subject Development Group other than suggesting to members to read about them. While the NCCA commissioned a report with lead author Mark Priestley in May 2019[22] covering the jurisdictions of Hong Kong, New Zealand and Singapore, these jurisdictions provide a detailed examination syllabus in addition to learning outcomes specified in curricula. The same is true for the IB programme, which provides extensive materials as part of the curriculum specifications in addition to learning outcomes. However, these detailed examination syllabi are not mentioned in the NCCA report, nor does the report address the role of learning outcomes in writing syllabi or specifications for high-stakes, externally assessed national examinations at the end of Senior Cycle in Ireland.

Indeed, a 2014 report by Áine Hyland[23] states that no jurisdictions could be found that use a specification template similar to that used by the NCCA, where only minimally detailed learning outcomes are used

> "while learning outcomes are a very valuable tool for identifying what learners should know and be able to do at the end of a course or programme, it is not appropriate to use learning outcomes alone to define a syllabus and its assessment (p. 5)."

Over a decade later, the NCCA has continued to use the same design for the Senior Cycle Reform and new Leaving Cert syllabi.

[20] Faulkner, F., Breen, C., Prendergast, M. and Carr, M. (2023). 'Profiling mathematical procedural and problem-solving skills of undergraduate students following a new mathematics curriculum'. International Journal of Mathematical Education in Science and Technology, 54(2), pp. 220–249.

[21] Education Act 1998 Section 41 (2) (d)

[22] NCCA Report, "Learning Outcomes: An International Perspective", May 2019.

[23] Hyland, Á. (2014) The design of Leaving Certificate science syllabi in Ireland: an international comparison. Report prepared by Áine Hyland for the annual conference of the Irish Science Teachers' Association (ISTA), 2nd April 2014.

The following is quoted from researcher Jenny Moon[24]

> "Learning outcomes are statements of essential learning, and as essential learning, they are written at minimum acceptable or threshold (pass/fail) standard. The learning described in learning outcomes is the learning that must be attained in order that the learner can pass. In effect, learning outcomes are written at the pass/fail point."

Further criticism of the NCCA specification template comes from diverse sources. A report of the Oireachtas Committee on Education[25] states

> "As part of Senior Cycle reform, a key priority for the Department of Education must be that the revised syllabus for each subject is far more detailed with comprehensive instructions for teachers. The Committee recommends that the National Council for Curriculum and Assessment (NCCA) reviews the proposed design of the new specifications to ensure teachers are properly supported and students are taught to the highest professional standards."

A report by the Association of Secondary Teachers of Ireland[26] based on a survey of 2,981 teachers states

> "Learning outcomes remain problematic. They are too broad, too vague and are lacking in guidance to the teacher on what students are expected to be able to do in order to show that they have achieved each learning outcome."

Further collection and analysis of widespread criticism of the NCCA specification template is given in two 2023 Hyland and Kennedy articles[27,28].

In summary it is clear that abundant studies from various researchers, stake holders and teachers have shown that the specification template being used by the NCCA generally for the Senior Cycle reform process is inadequate.

3.1 Benchmarking of Mathematical Content and Standard

In the IMS survey, 91.8% supported the call to benchmark the proposed curriculum changes against high-performing international mathematics curricula. There is no evidence that decisions about what mathematics content to include in the draft Leaving Certificate mathematics curricula, or the level of any mathematics content, have been informed by discussion of other comparable international syllabi.

[24] Jenny Moon, Linking Levels, Learning Outcomes and Assessment Criteria – paper accessed on http://www.aic.lv/bolona/Bologna/Bol_semin/Edinburgh/J_Moon_backgrP.pdf

[25] Oireachtas Committee (2022) Learning for Life. Joint Committee on Education, Further and Higher Education, Research, Innovation and Science (2022) p.11.

[26] ASTI (2022) ASTI Survey: Teachers' Experience of the implementation of the Framework for Junior Cycle

[27] Hyland and Kennedy (2023) Developing a new template for designing syllabi for Irish secondary school subjects Science (58) 2 p.10–17

[28] Hyland, Á. and Kennedy, D. (2023) 'Designing Junior Cycle and Leaving Certificate syllabi – the need for a new template', Ireland's Education Yearbook 2023, pp. 196–200.

Regarding the draft curricula Engineers Ireland[29] have stated:

> "Previous curriculum reforms have not consistently delivered the intended improvements in mathematical problem-solving. Engineers Ireland believes the lessons from those reforms should inform the current review, particularly before changes are made to the depth and breadth of mathematical content available to senior cycle students. Engineers Ireland is calling for the proposed changes to be assessed against high-performing international mathematics curricula and for their likely impact on students progressing to engineering and other mathematics-intensive third-level programmes to be fully considered before the new curriculum is finalised."

A wider and fuller analysis of international benchmarking for mathematical content is warranted and needed. However, for the jurisdictions listed on the NCCA background paper for mathematics, namely, IB programme, Singapore, Hong Kong and New Zealand, we give below a first approximate comparison of their HL syllabi regarding each of the major topics (at broad topic level) that have been omitted from the HL draft specifications.

- Complex numbers: are broadly covered in the specifications for 4 out of 4 of those jurisdictions,
- Mathematical induction: in 2 out of 4,
- Infinite series: in 3 out of 4,
- Binomial theorem: in 3 out of 4,
- Absolute value inequalities: at least 2 out of 4,
- Co-ordinate geometry: in 4 out of 4 (broad coverage),
- Trigonometry: in all 4,
- z-values and p-values: in 2 out of 4.

The best comparison may be with a more similar externally assessed programme, in this case the IB programme where students, as in Ireland, count 6 subjects for entrance to third level study. Of the eight items on the list of topics above that have been omitted from the proposed draft specifications, 7 out of those 8 topics (the last topic is in statistics) are on the syllabus of the more mathematical IB programme *Analysis and Approaches*.

Note that this is an initial approximate comparison of higher level courses for broadly illustrative purposes only, as a topic may be partially covered to different degrees (and IB and New Zealand offer two different higher course options).

In conclusion, international benchmarking, as required by NCCA statutes according to the 1998 Education Act Section 41 (2) (d), has not happened. This process should have been carried out at the

[29] https://www.engineersireland.ie/News/engineers-ireland-calls-for-review-of-proposed-senior-cycle\-maths-reform

very beginning of the review process and should have been presented to the members of the convened Subject Development Group as part of the initial context setting. The current review process for Leaving Certificate mathematics should therefore be paused and only restarted after such a benchmarking process has been fully carried out.

4 Student Preparedness for Further Study in STEM Fields

While no peer-reviewed evidence demonstrates that a cut in content in the Leaving Certificate Higher Level curriculum was warranted, the draft Leaving Certificate Mathematics Curriculum proposes wide-ranging cuts to the content taught to 5th and 6th year students. The table on the next page summarizes some of the proposed cuts to the Higher Level curriculum and their impact. Additions of new material at Higher Level are few and of far lesser magnitude than these cuts.

Although the draft curriculum for HL acknowledges the concepts of proof and abstraction when it states (Table 1 p.10) that "The learning outcomes present mathematical ideas that are meaningful and relevant and allow for the development of powers of abstraction, generalisation and the idea of rigorous proof, providing a solid foundation for further mathematical study", the topics normally used to introduce these concepts at HL have largely been removed. In particular, the more abstract, proof oriented topics — like induction, complex numbers, trigonmetric identities, geometry proofs, convergence of series — are all gone. So, while the draft claims to offer abstraction, generalisation and proof, the usual vehicles by which these are achieved have mostly disappeared. This reflects a significant mismatch throughout the entire document between stated laudable aims, such as (Table 1 p.10) "Students experience mathematics in an exploratory and reflective manner", and any real attempt or understanding of how to specify the way in which such aims could actually be achieved in the Senior Cycle classroom. The statements in Table 1 on p.10, for example, are not matched in any understandable sense to meaningful mathematical topics or learning outcomes.

Preparation for further study in STEM fields, particularly with the incredible explosion of AI in recent months, will in future rely less on computational and modelling skills and more on higher order skills, such as conceptual understanding and familiarity with all aspects of rigour, abstraction and proof. The IMS believes that we, as a country, should be increasing this type of deeper learning to prepare our students for the new STEM environment, but these are precisely the areas that the draft curricula are removing or deprioritising.

No rationale is provided for the decisions to cut extensive and wide-ranging content in the draft or explicate the (minimal) new content that is introduced. This is difficult to reconcile given that the rationale for the draft curriculum emphasises that students should develop an "understanding of the role of conjecture, argument and proof in mathematics" (NCCA, 2026, p.12), but these have been severely reduced in terms of content that young people must learn.

As well as reducing the content and skills that will benefit students for their futures in the world of work, further or higher education, these cuts to core mathematical content will likely impact students' experiences of mathematics, considerations of the utility of the subject, intentions to pursue STEM and

Topic	Details	Impact of Removal
Complex Numbers	Argand diagrams, complex conjugate, conjugate root theorem, De Moivre's Theorem, roots of unity	The most compelling example of the power of abstraction is dropped, along with the insights that it brings to solving polynomial equations and the connection of arithmetic to geometry.
Mathematical Induction	Students proved simple identities, inequalities, statements of divisibility	The main opportunity for students to exercise mathematical agency and experience the satisfaction of devising their own proofs is dropped.
Proofs of Theorems in Euclidean Geometry	Theorems 11,12,13 on ratios and similarity	Students have no opportunity to think about axiomatically defined systems, a cornerstone of modern mathematical theory.
Constructions in Euclidean Geometry	Constructions 16–22 on triangle centres	The memorable learning activity of integrating deductive reasoning and concrete physical tasks is withheld.
Infinite Series	Sum of an infinite geometric series	The useful and stimulating concept of an infinite sum is within easy reach. To omit it is a missed opportunity.
Trigonometric Identities	Derivation of formulae for $\sin, \cos, \tan$ of sums	These derivations answer the question "How do we know?" and highlight a warrant for knowledge that is unique to mathematics.
Absolute Value Inequalities	Solving inequalities of the form $\lvert x-a\rvert < b$, $\lvert x-a\rvert > b$	This is a routine skill but it requires disciplined thinking. It is essential for any form of quantitative analysis.
Coordinate Geometry	Angle between lines; splitting line segment in given ratio	The removal of these topics, combined with the elimination of all content on complex numbers, will greatly diminish students' awareness of the relationship of arithmetic to geometry.
Numerical Methods	Trapezoid Rule for estimating area	This was the only topic from numerical mathematics, a highly applicable and flourishing field. To remove it narrows the curriculum in a specific sense.

Table 1: *Table showing impact of topics cut from HL curriculum*

readiness to study finance, engineering, science or other further and higher education courses which incorporate mathematics.

5 Precision and Coherence in the Draft Specification

The IMS is of the view that the draft Leaving Certificate mathematics curricula are not mathematically coherent, specific or consistent. Furthermore, from an educator perspective, the draft curricula do not provide clarity in terms of subject content to be taught, the depth of treatment of content, and how students are expected to demonstrate their learning through assessment at Senior Cycle.

Throughout the draft Leaving Certificate mathematics curricula, the content of the "Students learn about" and "Students should be able to" columns are consistently poorly specified and mathematically incoherent, to the extent that it is impossible for a reader to discern what level of engagement is expected from students and with what content. Features of this general pattern of imprecision include:

- Conflation of the roles of definitions, formulae and theorems in mathematical discourse;
- Disregard for well established and universally agreed conventions of mathematical communication;
- Mention of very expansive topics with no clarity on what is to be studied;
- Inattention to points of technical complexity and nuance;
- Unrealistic and/or unrecognizable descriptions of what mathematicians do.

We mention four representative examples highlighting some of these issues, from four different strands of the draft curricula. **We emphasize that the imprecision demonstrated in these few examples is a systematic feature of the entire document, and not something that can be addressed by amendments to these items or others.** The problem of mathematical imprecision and incoherence can be resolved only by a complete rethinking of how the information is organized and presented to teachers and students. This process will require a partnership of practising mathematicians, teachers and other expert practitioners at every stage of the curriculum design process. Attention to the input of subject experts cannot be deferred or relegated to a final tidying-up step. A review of the structures of curriculum design, with a focus on accuracy and coherence of subject-specific knowledge, requires that the curriculum review process for mathematics be paused pending a review of these and the many other issues raised.

Unifying Strand: Working Mathematically
page 14: [Students should be able to] generate mathematical argument and proofs by

- sequencing logical statements
- using algebraic manipulation to logically deduce a conclusion
- using known results to logically deduce a conclusion.

This item on page 14 of the draft is the only clear mention in the entire document of proofs generated by students, so it is particularly important that it should reflect authentic human mathematical experience. The characterization of proving presented here, however, is thoroughly at odds with the very first learning outcome *U1.1: students should be able to appreciate how mathematicians work*.

Proof is not another word for rephrasing or verifying. It is, in the words of Hyman Bass[30], the "norm for certifying [mathematical] truth", a "unique method" that distinguishes mathematics from other fields of study[31].

The explicit association of algebraic manipulation to mathematical proof, in the absence of any reference to proof methods, is a misleading construct that obscures the role and purposes of proof in mathematics. Furthermore, it is not at all clear from this learning outcome what sorts of statements students will be proving. We note the absence of proof by induction in the draft, and the removal of the study of proofs in classical Euclidean geometry. In the current curriculum, these are two clear examples of opportunities for students to engage with the concept and purposes of mathematical proof.

To suggest that mathematical proofs are generated by "sequencing logical statements" is analogous to saying that poetry is created by "sequencing lines" — not literally false, but not how any poet would describe their craft. In addition, the source of the logical statements that students should be able to "sequence" is not stated. This is very problematic as it reduces the skill of proving to a decision about the order of steps in an argument. We note that *Sequence* does not appear in the *Glossary of action verbs* in Appendix 1.

Strand 1: Core mathematics: number and algebra
page 16: [Students learn about] prime numbers

This is the only appearance in the document of the term *prime number* and no further related comment is included in either column. The literature on prime numbers and their applications is vast and rapidly growing. What students should learn about prime numbers in Senior Cycle is, however, entirely unspecified. For example, will they study the Fundamental Theorem of Arithmetic? Will they learn about the distribution of primes? Will they learn about the utility of these numbers in technology and cybersecurity? All of these are appropriate topics for a higher level post-primary mathematics syllabus, but no guidance is provided for teachers or students of Senior Cycle mathematics in the draft curricula.

[30] Chair of the Mathematical Sciences Education Board of the United States National Academy of Sciences (1992–2000), and President of the American Mathematical Society (2001–2002)

[31] Hyman Bass. How Do You Know that You Know? Making Believe in Mathematics.
https://backend.production.deepblue-documents.lib.umich.edu/server/api/core/bitstreams/\9a424b31-2299-406b-ab04-836e5c21b23b/content

Strand 2: Exploring Shape and Space: Geometry and Trigonometry
page 32: [Students learn about] Formulae (list of eight items)

The list of "Formulae" referenced has eight items, including the definition of the tangent function, a mention of the inverse trigonometric functions (which are not formulae in any sense) and the names of three theorems that are central to trigonometry (the Theorem of Pythagoras, the Sine Rule and the Cosine Rule). It is not clear what students at Higher Level will learn about these three theorems. In a curriculum that aims to "provide a solid foundation for further mathematical study" (page 10) it is necessary to detail how students will experience these three fundamental theorems. The nature of engagement with concepts of core mathematical significance should be clearly specified, and at Higher Level that engagement should not be reduced to the formulaic. More generally, it is unclear how roles of definitions, formulae and theorems in mathematical exposition will be distinguished for students. They are all conflated in the "Formulae" list on page 32, in another example of the imprecision and inattention to the conventions of mathematical exposition that pervade the document.

Strand 4: Exploring change and relationships: functions and calculus
page 50: [Students learn about] limits and limiting behaviour ... continuous functions

These two items, listed under the headings "Function characteristics" and "Functions described graphically without formulae" are the only references in the entire document to the concepts of limit of a function and continuous function, both of which are central themes of the subject of calculus to which Strand 4 is devoted. These concepts are substantial, nuanced and not easily defined, either for modern students or in terms of the history of mathematical thought. It is unclear what students will learn about the definition and significance of the mathematical concept of *limit of a function*. The words "limits and limiting behaviour" provide no answer to this question, which is fundamental to any calculus curriculum. It is not clear how the definition of a continuous function will be presented and explored. If this occurs only in the context of "functions defined graphically without formulae" (again not a sound mathematical formulation) as suggested in the draft, students will not be equipped to embark on a study of calculus in a manner consistent with "a solid foundation for further mathematical study". These passing and vague references to the most fundamental objects of calculus – limits and continuous functions – are again incompatible with the aspiration in learning outcome U1.1: *Students should be able to . . . appreciate how mathematical ideas are cumulative and connected.*

Our call for coherence, specificity and consistency in the statements of content and learning outcomes is not a call for greater formality or for more specialist technical language or for greater length. It is a call to ensure that all teachers and students can have clarity on the depth and breadth of mathematical content that should be experienced and learned by Senior Cycle students. As an example of a curriculum specification for a comparable cohort that is clear, informative, succinct and mathematically coherent, we refer to the content specification for AS and A Level Mathematics produced by the UK Department

for Education[32].

6 The Alternative Assessment Component (AAC)

Minister Norma Foley in 2022 mandated an Alternative Assessment Component (AAC) as a 40% alternative assessment (not a traditional exam) across all Leaving Certificate examination subjects. Subject Development Groups at the NCCA have been told that the amount of this 40% allocation is strictly non-negotiable, although amendments have been made in some subjects as to the make-up of this 40%. Our initial discussion here deals with the AAC generally before later specializing to mathematics, as the IMS believes that the concept of the AAC has serious fundamental flaws that warrant its re-consideration across all subjects.

Last year, 2025, marked the hundredth anniversary of the Leaving Certificate examination. For the past hundred years the Leaving Certificate examination has held its place internationally as a transparent and fair assessment. In the words of Andreas Schleicher, Director for Education and Skills at the OECD[33],

> "The Irish school system has helped most people to succeed and has created a high level of equity with very strong outcomes",
>
> "the more judgment you bring in to this the more you will end up with social regression" and
>
> "the strongest performing and most equitable education systems do have something like Ireland which has a clear set-up and goal posts".

It is therefore regrettable, that after the hundredth anniversary of the Leaving Certificate examination, the NCCA are implementing an Alternative Assessment Component with a one-size-fits-all minimum worth of 40%, whose first consequence is likely to be the loss of that equity.

In several subjects already, the AAC takes the form of a project worth 40%. Generative AI can now easily write any project report in minutes. As teachers cannot oversee students' home AI use, this allows undetectable cheating and introduces significant disadvantages for students without additional resources from home and students from lower socioeconomic backgrounds.

The Hyland Report (2024)[34], following on from concerns of the Grenon, Kennedy and McCauley report (2024)[35], states that

> "the allocation of 40% of the assessment marks to an AAC is excessive. Of particular concern is the advantage that such a high proportion of marks for AACs will inevitably confer on

[32] https://assets.publishing.service.gov.uk/media/5a7f273a40f0b62305b85670/\GCE_AS_and_A_level_subject_content_for_mathematics_with_appendices.pdf

[33] Hyland, Á. (2023) 'Response to the "Leader Profile" interview by John Walshe with Andreas Schleicher in Leader Quarterly, Winter 2022', Leader Quarterly, Autumn 2023, pp. 34–35.

[34] Hyland, Á. (2024), "Ten years after the Hyland Report: achievements so far and future challenges", Science, 59(2), pp. 8–12.

[35] Grenon, M., Kennedy, D., and McCauley, V. (2024). Report of IUA Representative on the NCCA Biology, Chemistry and Physics Draft Specifications, as presented at the Subject Development Group Meetings in May 2024. Irish Universities Association, Ireland.

> students from socially and educationally advantaged backgrounds. Regardless of how carefully a student's work outside a supervised examination hall is monitored, students who have additional support and resources and/or access to additional advice and teaching outside school will be at a considerable advantage when preparing their AAC. Generative AI (e.g., ChatGPT) will exacerbate this advantage and will also make it virtually impossible for either the classroom teacher or the state examiner to verify or ensure that a student's project work is entirely their own work."

The State Examinations Commission (SEC) argue that no aspect of an examination can over-ride the fundamental principle of fairness. Indeed, they coined the expression "The fairness imperative"[36] in a State Examination Commission's 2018 report stating:

> "In the context of a high-stakes examination like the Leaving Certificate examination, fairness for all candidates is an overriding consideration. No candidate or group of candidates can be allowed to have an unfair advantage over any other arising from the nature of the test or the manner of its implementation. This has always been viewed as an imperative that trumps all other aspects of validity and has in the past imposed constraints on the structure and content of assessment for the Leaving Certificate."

The fairness imperative outlined above by the SEC shows that the continued implementation of the AAC conflicts with the NCCA's responsibility to the Minister as outlined in the Education Act 1998, Section 41 (2) (j), namely, "to promote equality of access to education generally" and also Education Act 1998, Section 41 (3) (b) "have regard to the desirability of achieving equality of access to, participation in and benefit from education".

Whatever the merits of a one-size-fits-all decision of a compulsory 40% AAC in 2022, the advent of freely available generative AI since then, and indeed its recent exponential explosion in ability over the past 6 months, makes this decision now untenable.

For mathematics, in particular, there are several other significant issues with the AAC proposals outlined in the draft curricula. The most obvious issue, and one which undermines its academic validity, is that the brief to be issued for the AAC at the end of fifth year must be *common across all three levels from Foundation to Ordinary to Higher level*.

While there may be merit in ensuring all learners can access the same assessment material, it will be very difficult to ensure that an appropriate level of challenge is available to all students. This is particularly important given the high-stakes nature of the Leaving Certificate mathematics examination.

Secondly, it is important to note that in the draft specifications there is no mention of allowable software or technology for the component called "Investigating with Data," worth 30%. The necessity of a computer for such an investigation is likely to be presumed as a necessity for any assessment involving non-trivial amounts of data, but this is unlikely to be achieved given the operational constraints of schools

[36] State Examinations Commission, Report, 2018, "On the trialling of the Assessment of Practical Work in Leaving Certificate Biology, Chemistry and Physics.", p. 111, Section 9.2.1. Available at https://www.ista.ie/wp-content/uploads/2018/12/Report-on-the-Trialling-of-the-Assessment-of-Practical-Work.pdf

under examination requirements. While paper-based assessments of statistical analysis is achievable, ensuring such an assessment is accessible to all learners will undoubtedly be a challenge and the awarding of grades across all levels for such an assignment may well undermine the worth of students' achievements.

There are further issues regarding the remaining component of the AAC, called "Investigating with Pattern," worth 10%, due to its inherent lack of clarity and depth of specification. Pattern is not a discernible mathematical topic and it is unclear what appropriate task might be provided to Leaving Certificate students that simultaneously provides sufficient challenge and is readily accessible to learners at all levels.

Note that the comprehensive Irish Universities Association report[37], covering the subjects of biology, chemistry and physics, recommended that the AAC be 20%.

> "Given the feedback from our IUA colleagues and our experience in initial teacher education and university teaching, we cannot see how the proposed Additional Assessment Component model is feasible without huge investment in our school science laboratories and the employment of laboratory technicians. Therefore, we recommend that an alternative model be developed to give students credit for carrying out laboratory practical work investigations and that the 40% of marks be reduced to 20%."

The experience from third-level institutions worldwide is that to maintain academic integrity, continuous assessment components are moving either to fully invigilated in-person events or are being reduced to quite low-stakes events. Anything else compromises the integrity of the assessment[38]. If the integrity of a Leaving Certificate assessment component worth 40% cannot be guaranteed, it should be paused for consideration and review.

Little information is available in the draft specifications regarding the single proposed Leaving Certificate mathematics exam worth 60% to be taken at the end of sixth year.

In summary, the 2022 proposal of a compulsory 40% Alternative Assessment Component across all Leaving Certificate subjects merited further critique and debate at the time. Given advances in AI since then, the assessment is likely no longer justifiable in terms of fairness and integrity. In mathematics, the proposed AAC has serious additional concerns, including the requirement for a common assessment brief from Foundation level to Higher Level, the very poor specification of the assessment, and the likely lack of availability of laptops. We note that circa 700 signatories from industry, tech, academia, teaching, parents and more to the `savemaths.ie` website call for the AAC and its compulsory 40% allocation in Senior Cycle mathematics to be lifted.

The mathematics curriculum reform process must now be paused until fundamental problems with the AAC, among other things, are resolved.

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[37] Grenon, M., Kennedy, D. and McCauley, V. (May 2024), Report of IUA Representatives on the NCCA Biology, Chemistry and Physics Draft Specifications, presented at Subject Development Group meetings.

[38] A. Hickey, C. Ó. Faoláin, J. Healy, K. Nolan, E. Doheny and P. Cuffe, "A Threat Assessment Framework for Screening the Integrity of University Assessments in the Era of Large Language Models," 2024 IEEE 8th Forum on Research and Technologies for Society and Industry Innovation (RTSI), Milano, Italy, 2024, pp. 7–12, doi: 10.1109/RTSI61910.2024.10761151.