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Research Article

Widening access to advanced mathematics: Teachers' perspectives on the impact on secondary school teaching

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ABSTRACT

In Ireland, mathematics is a core subject at secondary school and is chosen as a subject by almost the entire school leaving population. It can be taken at two levels: ordinary level and higher level (HL). In 2012 an incentive to increase participation at HL was undertaken by the Irish government. This incentive came in the form of bonus points (towards gaining access to their chosen university programme) to anyone who achieved 40% or above in this examination. It is the only subject (out of 53 offered) in which bonus points are awarded. The incentive was successful in that it doubled participation within ten years. The impact of this incentive on teachers however is the focus of this research. The goal of this study is to demonstrate the extent of the demands placed on teachers of advanced mathematics, both in the quantity of material they are required to cover and the depth they are expected to reach, all while managing larger class sizes and greater diversity in students' mathematical abilities. This study is highly relevant to an international readership, as it explores how incentivising participation in a secondary school subject, and the resulting rise in student numbers and broader range of ability levels, can profoundly affect the teaching of the subject. The teachers interviewed in this study reported difficulty balancing larger, more diverse classes with the demands of a challenging syllabus and described how lesson pacing slowed to accommodate students with lower prior attainment, limiting time for deeper learning opportunities.

Keywords: mathematics education, mathematics examinations, summative assessment, advanced mathematics, incentivisation

INTRODUCTION

Since the early 2000s, both the UK and Ireland have expressed ongoing concerns about the insufficient number of graduates entering science, technology, engineering, and mathematics (STEM) fields, a trend that raises potential risks for national well-being and development (Bennett et al., 2014; Homer et al., 2018; Mujtaba et al., 2015; Reiss & Mujtaba, 2017; Usman, 2015). Similar issues have been reported in France (Arnoux et al., 2009) and Australia (Hine, 2018). A key element of this issue is the recognition that a strong and sustainable economy depends on a continuous flow of graduates who are highly skilled in STEM disciplines (Expert Group on Future Skills Needs, 2008; Reiss & Mujtaba, 2017). Among these disciplines, mathematics holds a particularly central role, serving as the foundational language and toolset for the others. It is widely acknowledged as a core competency essential for sectors driven by innovation and technological advancement, making proficiency in mathematics especially vital (Expert Group on Future Skills Needs, 2008; Fitzmaurice et al., 2021). Its strategic significance is also reflected in its function as a gateway subject, often required for access to higher education programmes (Johnson & Fitzmaurice, 2025). Empirical studies further highlight that earning a qualification in mathematics at school is associated with improved career prospects and is positively linked with higher career salaries (Mujtaba et al., 2014).

Many countries have turned to offering incentives to encourage further engagement with mathematics in secondary school. In Western Australia, from 2017 students studying mathematics methods and mathematics specialist courses received a 10% bonus on their final scaled scores to enhance participation rates (Hine, 2023). Similarly in Queensland, enrolment in mathematics C courses, a high-level mathematics subject offered in senior high schools, increased over a five-year period due to the offer of bonus points (Hine, 2023). In 2015 the Israeli Ministry of Education successfully introduced a 'give five' programme to increase the study of the most advanced level of mathematics that can be studied at high school level, 5-unit math. Students who complete this module successfully are awarded bonus points towards their chosen university programme (Davidovitch & Yavich, 2018; Maagan & Zussman, 2019). In 2012, a bonus points incentive (BPI) was introduced in Ireland to increase student participation in leaving certificate[1] higher level (HL) mathematics–the most advanced mathematics course available at secondary school. Under this initiative, students who achieved a minimum of 40% in the final examination were awarded additional points toward their university admission score. The BPI has had a significant impact on student participation rates at HL (O'Meara et al., 2020; Prendergast et al., 2020; Treacy, 2017). The primary intention was to double participation rates which it successfully did within ten years of it being introduced. In 2011, 16% of the school leaving cohort took mathematics at this level, by 2019 the proportion increased to 32.9% (Prendergast et al., 2019). In 2024, the figure had risen to 36%. Even though a thoroughly revised mathematics curriculum was introduced in 2012 to enhance the teaching and learning of mathematics at secondary school in Ireland and may have had some impact on participation rates at HL mathematics, there is empirical evidence to show that the attainment of bonus points is the most compelling reason why students partake in HL mathematics (O'Meara et al., 2023). The lure of additional points surpasses mathematics as a requirement for their desired university programme or enjoying the doing of mathematics (O'Meara et al., 2023). Unsurprisingly, parents substantially influence their children's decision to participate in HL mathematics as well (O'Meara et al., 2023), but this is often driven by the securement of bonus points (Johnson & Fitzmaurice, 2025). A serious concern regarding the increase in participation relates to the fact that there is a cohort of participants now present that struggle with the breath, depth and rigour of content involved. HL mathematics classes now comprise a greater level of diversity in terms of mathematical ability than in previous years (Treacy et al., 2019).

This study is a qualitative investigation into the impact of the government incentive in Ireland aimed at increasing participation at the most advanced level of mathematics that can be taken at secondary school level. This study takes an in-depth look into what constitutes HL mathematics at secondary school in Ireland, the pressing curricular responsibility borne by teachers, and how the increase in participation has affected their practice. By foregrounding the teachers' voices, this research provides an opportunity for educators to share their firsthand experiences and insights, ensuring their opinions on the challenges and opportunities in teaching HL mathematics are heard. Within this paper, the following research questions are addressed:

1. How does incentivising the study of advanced mathematics at secondary school impact on the teaching of the subject?
2. What are the challenges teachers face when teaching advanced level mathematics?

MATHEMATICS EDUCATION IN IRELAND

In Ireland eight years of primary school precedes five or six years of secondary school. The secondary school academic year spans nine months, beginning at the end of August and finishing up towards the end of May. Schools are obligated to open for at least 166 school days in the academic year. The first three years of secondary education, the junior cycle, culminates with the junior cycle examination. Mathematics is a core subject and can be taken at either HL, ordinary level (OL) or foundation level. In the fourth year of secondary school, there is transition year (TY), an optional year where there are no examinations and students gain the opportunity to do work experience, entrepreneurship and school trips in addition to studying academic subjects (Clerkin, 2012). The guidelines for TY state that it is not to be used as an additional year of study for

[1] The leaving certificate is the final examination of secondary education, and the gateway to tertiary education in Ireland.

Table 1. Points allocated for each grade at both HL and OL in Ireland

HL grade	Points	OL grade	Points
H1	100		
H2	88		
H3	77		
H4	66		
H5	56	O1	56
H6	46	O2	46
H7	37	O3	37
H8	0	O4	28
		O5	20
		O6	12
		O7	0
		O8	0

the final two years of schooling, the senior cycle. Approximately 80% of all secondary school students participate in TY. The senior cycle concludes with the leaving certificate examination.

The state (junior cycle and leaving certificate) examinations begin on the first Wednesday in June and take place over the course of three weeks. Students study between six and eight subjects for leaving certificate. While mathematics is not officially compulsory, a pass in leaving certificate mathematics is required for entry to most degree programmes, therefore because of this gatekeeper role to university it is taken by more than 97% of the leaving certificate cohort (O'Meara et al., 2023). Students have the option of studying mathematics at two different levels: HL or OL. Typically, students need to have done HL mathematics in the junior cycle, if they wish to study HL mathematics for the leaving certificate examination. Assessment for junior cycle mathematics and leaving certificate mathematics has historically been a timed, proctored, written, closed book examination. Up until 2021, the junior cycle mathematics assessment consisted of two 2.5-hour examinations at the end of year three. This has since been replaced with a single 2-hour examination, complemented by two classroom-based assessments (CBAs). For the CBAs, students select a mathematical problem of personal interest, apply their knowledge to solve it, and then submit an individual written report detailing their work once completed. The HL mathematics assessment remains a summative two paper (2.5 hours each) examination which takes place in June of students' final year. In January or February before the leaving certificate examination, students complete the 'mock exams', which are essentially a trial run of the leaving certificate, replicating its format, content, exam conditions and timing.

The Central Applications Office (CAO) points system governs access to university in Ireland. Places on degree programmes are allocated on a points basis. The difficulty of, and demand for, a particular programme determines the points required to gain access to the programme. In the leaving certificate, students earn points based on the grades they achieve in each subject, as shown in **Table 1**. A student's total points score from their best six subjects determines the degree programmes they may gain access to. A H1 (HL grade 1) in any subject is worth 100 points. However, mathematics is an exception due to the BPI mentioned earlier: students who achieve a minimum of 40% (H6 grade) in the HL mathematics exam receive an additional 25 points. As a result, a H1 in mathematics yields 125 points, and the maximum total points a student can earn is 625.

In line with the introduction of the BPI, a new mathematics curriculum was introduced at secondary level in Ireland, which may also have contributed to increased participation at HL mathematics. It was called 'project maths'.

Project Maths

'Project maths' was introduced to replace a curriculum that had become so exam focussed it was impacting adversely on how mathematics was being taught in the classroom (Gill, 2006; Johnson et al., 2019). Project maths introduced a series of progressive changes to the mathematics curriculum, encompassing not only the content taught but also the teaching methodologies (pedagogy) and the ways students' understanding was assessed. These reforms aimed to make mathematics more relevant, engaging, and focused on problem-solving skills. Mathematical applications and the interconnectedness of mathematical concepts now also played a bigger role in the new curriculum which meant that sections of the syllabus could no longer be omitted, which had previously been the case. Context and applications now featured heavily, which was a significant departure from examination papers that assessed skills only. Where previously an exam question would focus solely on Trigonometry, now a repertoire of knowledge and skills across a range of mathematical areas was required to answer a question effectively, emphasising the connections within and across mathematical concepts. However, while the examination paper formats changed, the two 2.5-hour examinations for HL mathematics assessment stayed the same. The syllabus now spans five strands (statistics and probability, geometry and trigonometry, number, functions, and algebra) and was implemented on a phased basis starting in September 2010.

The Aim of Leaving Certificate Mathematics

The National Council for Curriculum and Assessment (NCCA)[2] (2015) states that the aim of leaving certificate mathematics is 'to develop mathematical knowledge, skills and understanding needed for continuing education, life and work' (p. 6). There is a strong emphasis on building connected and integrated mathematical understanding. While there are five strands of content, the syllabus explicitly states that 'the strand structure of the syllabus should not be taken to imply that topics are to be studied in isolation. Where appropriate, connections should be made within and across the strands and with other areas of learning' (NCCA, 2015, p. 8). Teaching mathematics in appropriate, realistic contexts is endorsed as a means of demonstrating the connections within mathematics, and between mathematics and other subjects, and real life. Applications of mathematics are encouraged as a means of demonstrating the utility value of the subject to students' current and future lives. Problem solving is viewed in a similar vein in that it should feature throughout all aspects of the teaching and learning, rather than introduced as a standalone component. The NCCA (2015, p. 12) state that 'the focus should be on learners understanding the concepts involved, building from the concrete to the abstract and from the informal to the formal.'

Findell et al. (2001) framework for mathematical proficiency underpins the objectives of leaving certificate mathematics. According to Findell et al. (2001) mathematical proficiency incorporates conceptual understanding (understanding why a procedure or algorithm works), procedural fluency (dexterity in algorithms and application of rules), strategic competence (the ability to formulate and solve familiar and unfamiliar mathematics problems), adaptive reasoning (ability to reason, defend arguments and think and communicate logically) and productive disposition (perseverance and the ability to see the efficacy of mathematics). In addition, information processing, being personally effective, communicating, critical and creative thinking, and working with others are listed as five key skills that should be embedded in the teaching and learning across the entire senior cycle curriculum. The policy documents state that achievement of these key skills enables students to reach their full potential. HL mathematics at leaving certificate specifically is designed to underpin further study of mathematics should a student choose to do so. It is stated that they should be introduced to the concept of proof and 'particular emphasis can be placed on the development of powers of abstraction and generalisation' (Department of Education and Skills, 2015, p. 11).

The Difference Between Ordinary and Higher-Level Mathematics

According to the NCCA (2015), the leaving certificate mathematics syllabus for both OL and HL are designed as 180–hour courses of study. The learning outcomes specified at OL are *a subset* of the learning outcomes for those studying at HL. This means that students who take the HL mathematics course are required to understand the OL syllabus *in addition* to what is required for HL mathematics.

Table 2 presents the learning outcomes for the topic of complex numbers, which forms part of the Number strand, across both the OL and HL syllabi. **Table 2** illustrates the distinctions between these two programmes of study, with the OL learning outcomes detailed in the left column and the HL learning outcomes–including all OL outcomes plus additional, more advanced learning goals–listed in the right column. Analysis of these specific learning outcomes highlights the increased cognitive demand, level of abstraction, and depth of application required of students undertaking the HL mathematics option.

[2] The National Council for Curriculum and Assessment is a statutory agency under the department of education that collaborates with education stakeholders to develop and shape Ireland's educational curricula.

Table 2. Learning outcomes for complex numbers on the leaving certificate syllabi [Source: NCCA (2015, pp. 29, 39)]

Students working at OL should be able to …	In addition, students working at HL should be able to …
-investigate the operations of addition, multiplication, subtraction and division with complex numbers C in rectangular form $a + ib$, -illustrate complex numbers on an Argand diagram, -interpret the modulus as distance from the origin on an Argand diagram and calculate the complex conjugate.	-calculate conjugates of sums and products of complex numbers, -use the conjugate root theorem to find the roots of polynomials, -work with complex numbers in rectangular and polar form to solve quadratic and other equations including those in the form $z^n = a$, where $n \in Z$ and $z = r(\cos\theta + i\sin\theta)$, -use de Moivre's theorem, -prove de Moivre's theorem by induction for $n \in N$, -use applications such as nth roots of unity, $n \in N$, and identities such as $\cos 3\theta = 4cos^3\theta - 3\cos\theta$.

The learning outcomes displayed above in **Table 2** demonstrate that OL mathematics aims to provide students with fundamental numerical, algebraic, and geometric skills, while HL mathematics builds upon these foundations to introduce more abstract and sophisticated concepts. A clear demonstration of the difference in levels can be observed by examining the distinctions in breadth of content (**Table 2**), depth of understanding, and rigour and cognitive demand between the OL and HL mathematics syllabi. These contrasts are illustrated next using the topic of complex numbers as a representative example.

Depth of understanding

While the OL curriculum emphasises procedural fluency and fundamental comprehension, the HL curriculum demands a more theoretical and abstract understanding of complex numbers. OL students focus primarily on computational skills and basic geometric representations, whereas HL students are required to engage in formal proofs, generalizations, and applications to higher-order equations. For example, where an OL student may be required to calculate the modulus of a complex number and identify it as a distance from the origin, a HL student should be able to extend this concept to polar coordinates and employ de Moivre's theorem to compute complex powers and roots.

Rigour and cognitive demand

Rigour is the 'measuring rod of mathematics' (Freudenthal, 1973, p. 147). It is typically characterised by the level of reasoning and abstraction required. The OL syllabus primarily focuses on tangible computations and straightforward visual representations. In contrast, the HL syllabus demands greater abstraction. Here students are required to engage in proof-based reasoning and apply complex numbers to a much broader range of contexts. For example, proving de Moivre's theorem by induction introduces students to mathematical proof techniques, reinforcing logical reasoning and critical thinking skills. Furthermore, the application of complex numbers to polynomial equations and trigonometric identities demonstrates an integration of many mathematical areas and concepts, demanding a significantly HL of cognitive flexibility on the part of the students.

The outline of the complex numbers learning outcomes above serves as a clear example of the increased breadth, depth, and rigour required at HL compared to OL mathematics. While OL provides students with essential computational tools and visual understanding, HL challenges students to engage with theoretical concepts, proofs, and advanced applications. This distinction underscores a significant challenge facing teachers to effectively deliver the HL curriculum within the same timeframe.

An analysis of the leaving certificate mathematics examination papers additionally helps to identify differences between OL and HL. Paper one is divided into two sections: Section A, "concepts and skills," which comprises six questions worth a total of 150 marks. The complex numbers question is in this section. Section B of the paper, "contexts and applications", comprises 150 marks and here there are four questions. Students must complete any five questions from section A and any three questions from section B within the 2.5-hour limit. To illustrate the differences further, an analysis of the complex numbers of questions from the 2024 leaving certificate OL and HL examination papers is conducted to highlight the contrasts between the two levels. As shown in **Figure A1** (**Appendix A**), correctly completing the OL complex numbers question requires students to identify complex numbers on an Argand diagram, calculate the modulus of a complex number using the appropriate formula, convert a complex fraction to standard form, and identify the complex conjugate of a complex number on an Argand diagram. The corresponding HL question, shown in **Figure B1** (**Appendix B**), requires a knowledge of various broader complex number concepts. It covers a wide range of complex number concepts, including solving quadratics, polar form, powers of complex numbers, and angles in the Argand diagram.

The HL question is significantly more challenging than the OL question in terms of difficulty, rigour, breadth, and depth. The OL question primarily assesses foundational knowledge of complex numbers, including reading from an Argand diagram, computing moduli, simplifying fractions with complex denominators, and identifying conjugates. These are essential but relatively straightforward tasks that require procedural fluency and basic algebraic manipulation. In contrast, the HL question requires a deeper conceptual understanding and the ability to apply advanced techniques such as solving quadratic equations with complex solutions, using de Moivre's theorem for exponentiation in polar form, and calculating angles between complex numbers using arguments and trigonometry. The rigour is also higher in the HL question, as it demands algebraic manipulation in both rectangular and polar forms, requiring fluency in multiple representations of complex numbers. Additionally, the breadth of the HL question extends beyond standard algebraic operations to trigonometric, polar, and geometric interpretations of complex numbers, making it a much more comprehensive assessment of a student's understanding. The depth of knowledge required to complete the HL question is also greater as it not only asks for solutions but also requires insight into how complex numbers appear geometrically, specifically regarding rotation and magnitude transformations in the complex plane.

Having outlined the key differences between OL and HL mathematics, along with the associated challenges in content volume and depth of understanding, it is important to place these observations within the broader context of the leaving certificate mathematics curriculum. This section highlighted the substantial volume of content that teachers must cover within a limited timeframe at HL, as well as the significant academic rigour demanded of students who wish to fully engage at this level. Additionally, it underscores the depth of knowledge, understanding, and experience required of teachers to deliver the course effectively. It also draws attention to the considerable challenge faced by students striving to secure the additional 25 bonus points awarded for achieving a passing grade at HL. These factors raise important questions about how the incentive of bonus points influences teachers' practice and what specific challenges are encountered in delivering such a demanding curriculum. The following section explores these issues through the insights of a sample of teachers currently teaching HL mathematics.

METHODOLOGY

Teacher Interviews

This research falls under the umbrella of an overarching study which was designed to investigate the existence and scale of a gap between the intended and implemented HL mathematics curricula (Johnson & Fitzmaurice, 2025). In the primary study, document analysis on the main leaving certificate policy documents in addition to semi-structured teacher interviews were undertaken to answer the research questions. The semi-structured interviews, conducted with a selection of HL mathematics teachers to probe their perception and enactment of the curriculum, lasted approximately 50 minutes and were administered and recorded on Microsoft Teams. The interview schedule was guided by the themes that emerged from the document analysis. Topics that were discussed included: teachers' opinions of the new curriculum, responsibilities and pressures related to teaching HL mathematics, syllabus content, time to teach the syllabus, pedagogical strategies, and assessment.

Participants

Nine teachers volunteered to participate in this research study. Participants were recruited via social media. In total, the teachers had between six- and 33-years' experience teaching mathematics and between five- and 25-years' experience of teaching the HL mathematics syllabus. All participants gave informed consent for inclusion before they participated in the study. The Education and Health Sciences Research Ethics Committee at the University of Limerick granted approval for this study to be conducted (project ID: 2022_03_03_EHS (ER)).

Limitations

While this study provides valuable insights into the perspectives of HL mathematics teachers regarding the challenges of delivering the syllabus, some limitations should be acknowledged. This study involved interviews with only nine teachers. While qualitative research does not aim for statistical generalisation, the small sample limits the breadth of perspectives captured. Furthermore, participants volunteered or agreed to be interviewed, which may introduce self-selection bias. Often people with strong opinions, positive or negative, are more likely to participate (Stone et al., 2024). The findings reflect the experiences and opinions of these specific participants and may not represent the full diversity of views among HL mathematics teachers in Ireland. Finally, the study centres solely on the experiences and views of teachers. While these are crucial, the absence of student or policymaker voices means the findings may not fully capture the broader systemic or student-focussed aspects of the issue.

Analysis of Teacher Interviews

An inductive thematic analysis approach was applied to analyse the teacher interviews, where codes and themes emerge from the data rather organically. Braun and Clarke's (2021) six-step process for identifying, analysing, and reporting qualitative data was followed when conducting the analysis of the teacher interviews. The six-steps of the analysis process are familiarising yourself with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. The themes were identified using an inductive coding technique. The nine interviews were initially reviewed independently to allow for familiarisation with the data. Preliminary codes were then generated individually in NVivo before being collated collaboratively to form overarching themes. All themes were subsequently reviewed, and through a process of merging, discarding, or renaming, a final list of themes was established (Braun & Clarke, 2021).

TEACHER INTERVIEW FINDINGS

Excerpts from the transcriptions have been edited for clarity. Words such as "amm" and "like" as well as word repetitions and intermittent use of "yeah" or "ok" by the researchers to indicate agreement during the interviews were removed.

The theme of *time* emerged as the most prominent and recurrent challenge discussed by the HL mathematics teachers. Many expressed concerns over the limited time available to effectively cover the curriculum, with teacher1 stating plainly that 'my main issue is always time'. Several teachers described time constraints as a root cause of other difficulties they experience, a point made clearly by teacher3, who noted that 'it just did take so much time you know, so I think all roads lead back to time'. Despite this, teacher3 acknowledged that even reducing the volume of content might not resolve the issue entirely, explaining: 'you'll always get through the content, whether how deep you get into the content, that's the question'. The challenge, then, is not only about course completion but also about the depth and quality of instruction. This tension between time and pedagogical intent was also highlighted by teacher7, who explained that time constraints often force them to move away from the student-centred approaches encouraged by the curriculum. They remarked that while there are many beneficial 'self-discovery' activities available, 'project maths has loads of them', they are 'very time consuming', and therefore seldom used in practice. As they reflected, 'it would be nice to give them a go if you had the time'.

A closely related challenge voiced by several teachers was the need to cover the entire course within the allocated timeframe to ensure students have covered all topics in some capacity before the final state examination. Teacher6 illustrated this point by stating: 'there's lots of things that I'd like to do in leaving certificate HL maths, but I don't get the opportunity to because of that time pressure that you feel'. Although this sentiment was widely shared, not all teachers felt equally burdened. For example, teacher2 offered a different perspective, saying: 'when it comes to teaching the actual syllabus, to me personally, there's no pressure. I think it's a great syllabus. I feel confident teaching it'. However, even teacher2 ultimately acknowledged a familiar limitation, observing that while the syllabus can be covered within the given timeframe, the depth of teaching is compromised: 'we don't feel we have the time to teach the topics at the deep level that's required. We're hindered by the state exam. The pressure to finish the course by Christmas in 6th [final] year to start preparing for mocks'. In summary, the time challenge faced by HL mathematics teachers appears to manifest in different ways: some feel pressure to complete the course, others feel constrained in how they teach it, and many feel unable to implement the kinds of student-centred activities envisioned in the curriculum. As teacher4 aptly put it: 'at the moment, I think we've found an equilibrium. We found a way of being able to cope. We are coping and that is all we can say … and it is very, very stressful, but we are coping'.

Delving further into the theme of time, some teachers highlighted how they struggle to cover the curriculum content within the allocated time and how this allocated time can vary significantly between different schools. Teacher1 pointed out that 'there just seems to be a huge disparity across schools about how much time they are given and the expectation as well that maths teachers teach outside the timetable, and so many of us do it'. Teacher6 reiterated this point by stating that 'there is definitely a common trend there across different schools that they feel that they need extra time to teach the course effectively and to cover everything in the detail that they want to cover it'. Even among the small number of teachers in this research study there was a clear difference in the amount of time allocated to teach the content. Teacher3 stated 'I think we have a good enough time' and teacher4 echoed this sentiment by stating that 'on the basis of the time that schools, generally speaking, have given to departments to actually teach the course, it is probably enough'. That said, even teachers who seemed content with their allocated time for mathematics instruction noted that if they were to miss classes due to bank holidays or if instructional time was removed from the subject, they would find it very challenging to cover all the content. Teacher7 noted that although they felt that the time they were currently allocated to cover the content 'is probably good in comparison to some schools', they did state that they 'can't even imagine schools who function under less … the time pressure must be massive'.

Challenges related to the theme of 'mathematics content', and more specifically the amount of content on the HL syllabus, are closely aligned with the theme of time. Teacher2 pointed out that 'if you just take how it's supposed to be taught in two years or whatever, it is too much. It's too much content'. Other teachers echoed this sentiment by saying things like 'there's too much. It's overly long' (teacher7) and 'it's way too long' (teacher8) when asked for their opinion on the amount of content currently on the curriculum. Although there were negatives regarding the amount of content on the curriculum, there were also positives mentioned by some teachers. Teacher5 pointed out that 'content is good; content is interesting; content is relevant, but you know, there is an awful lot to it'. When asked if they would prefer more time to cover the content or less content to cover, most of the teachers advocated for less content. Several teachers pointed out that some topics on the syllabus are a repetition of junior cycle topics and that perhaps these could be removed. Others highlighted how they would prefer a reduction of content so that 'we can teach them [the students] more deeply' (teacher2). Teacher5 echoed this sentiment by stating that the syllabus would be better if they could 'scrape off a couple of little things around the edges to allow more time to delve into the concepts and develop a little bit more understanding of them rather than just everyday be "boom, let's move on, let's move on, let's move on"'.

Another significant challenge highlighted by the teachers was the overall ability of the students now opting to study mathematics at the HL. Many of these students, according to teacher9, 'are not at the level.' Teacher7 observed that the incentive of bonus points means 'more students obviously are trying their hand at it [HL mathematics],' resulting in an increase in students choosing this level, many of whom 'might not be able for it.' Teacher5 emphasised that this issue isn't confined to the leaving certificate. It begins earlier, during the junior cycle, where second-year students (around 14 years old)–or more accurately, their 'mommies and daddies', are choosing HL mathematics because they 'are thinking bonus points when they [the students] are in 5th year.' The impact of students' ability is especially noticeable in schools where classes are further streamed by their perceived ability. In such cases, teacher1 pointed out that being placed in the lowest of the HL groups doesn't necessarily mean students 'can't do it [the mathematics],' but rather that 'it takes them a long time to actually grasp it.' This slows the pace of teaching and puts added pressure on teachers to balance content coverage with students' needs. A related issue, as teacher7 noted, is the lack of capacity in some schools to allow students to drop down to OL. As a result, teachers end up 'carrying weaker students through for much longer,' which increases pressure on teachers and stress on students. Several teachers discussed how the wider range of abilities in HL mathematics classes has slowed lesson pacing. As teacher9 explained, 'you have to slow down and then you can't cover everything' because 'it's just too much for the students.' The growing diversity in ability among HL mathematics students has also impacted student confidence and the effort they put into the subject. Teacher6 remarked that 'confidence has a huge part to play in maths,' but frequent low scores on classroom assessments can 'really demoralize them [the students].' Teacher7 echoed this, noting that when students struggle, 'they get turned off' from the subject, leading to 'low confidence.'

According to teacher 2, another key challenge faced by teachers of HL mathematics is that 'the assessment didn't change' [since the curriculum was overhauled], and 'as the years have gone on … people have just naturally gone back' to teaching in isolation and over-relying on the textbook. They also remarked how introducing options into the exam in recent years is challenging too as 'you're just going to get away from linking topics together', where teachers may decide to skip topics and omit them, which fundamentally 'gets back to what project maths is not supposed to be'. Continuing this focus on the exam, many of the teachers appeared discontented with the exam and offered suggestions around how they felt the final summative examination should be improved. Some spoke to the idea of choice on the paper and felt that this was a positive recent addition. Teacher3 pointed out how because of COVID-19, some choice regarding questions was introduced into the summative exam which they felt was a good addition and something 'that should maybe be looked at permanently'. Teacher5 also felt that the inclusion of choice could be a positive amendment to the examination going forward but stressed that 'you have to be careful with choice'. They articulated how when given too much choice you increase your likelihood of making a poor choice and so they believed that there should be core questions that must be attempted and then a small pool of questions where students choose 'one or two questions'. Teacher9 spoke to how the inclusion of choice was a good thing in that the students are under so much pressure in the exam and that there is 'always going to be something that trips you up on the day', so by offering students a choice they can hopefully choose to avoid questions that otherwise could be problematic for them.

Teachers additionally emphasised the challenge of preparing students to navigate the examination papers within the allotted time, noting that the limited time available for each question leaves little opportunity for students to reflect on their answers. Some of the teachers felt that there were too many questions on the exams and that this did not afford students time to think within the exam. Teacher3 pointed out that for many students, studying HL mathematics it is 'not that they don't understand it', but it is the fact that 'everyone has different maths speeds' that is causing them to not reach their full potential in the exams. Teacher5 echoed this idea and pointed out that if the goal of the curriculum is to develop problem solving skills, then 'time shouldn't be an issue'. They stated how when it comes to solving a problem 'some people can go away and it clicks with them straight away', but that for most people 'you have to go and think about it [the problem] for a few minutes', which is not really factored into the timing structure of the exam papers. They felt that the exams should 'take that pressure off' the students and instead allow the students to 'think about it and come back to it' so that they have a higher likelihood of answering the question fully, and correctly.

Teachers highlighted the challenge of meeting student and parent expectations to support students in passing the exam and achieving the 25 bonus CAO points. Teacher5 pointed out that students often stress that they 'need the points' and that they 'have to get 25 bonus points.' Teacher5 pointed out that some students now doing HL mathematics spend 'two hours studying every night and only come away at 40%', and that the additional time they spend studying HL mathematics might be better spent on subjects 'that they're probably going to work in and excel in in the future that suits their strengths'. Teacher6 echoed this sentiment by noting that even when students fail their mock exams they still insist on remaining in HL mathematics as 'the idea of changing level isn't an option because they say, "I need the points".' Teacher6 did note that sometimes the decision to remain is the correct decision on the part of the student and that it is 'the goal of any teacher to try and help students to achieve their potential', but that 'there is definitely pressure for lower ability students' to pass the exam. Parental pressure was another challenge that the teachers highlighted in the interviews as teacher1 noted that 'parents obviously want their kids to do well in maths'. Teacher3 pointed out that parental pressure can be difficult for both students and teachers to deal with. Students are being constantly told by parents that they need to do HL mathematics for the bonus points and teachers are constantly being contacted by parents who are 'interested in how they're doing in maths, and they'll be phone calls in and just emails in'. Teacher4 even highlighted that parental pressure can begin long before the leaving certificate with parents of second year students (14-year-olds) 'who you would feel would be OL students and would be definitely OL students' contacting the school to insist that their children are placed in a HL stream. Teacher7 offered a succinct summary of the connection between these two pressures by nothing that 'parent pressure is always there … but the bonus points have pushed that [pressure] higher'.

DISCUSSION

The BPI in Ireland is responsible for more than doubling participation since it was introduced in 2012 (O'Meara et al., 2020). Similar incentives and resulting increases in participation have been reported in Australia (Hine, 2023) and Israel (Davidovitch & Yavich, 2018; Maagan & Zussman, 2019). This was the explicit intention of the Irish Government, and it has been truly successful on this front. However, the findings of this study indicate that the increase in participation is not unequivocally positive. The enticement of additional points means that many students end up taking a challenge and risk that perhaps they should not. In relation to the first research question, how incentivising the study of advanced mathematics impacts teaching, teachers are now faced with unprecedented class sizes and levels of abilities and diversity in their HL mathematics classrooms (O'Meara et al., 2020). Larger classes with more diversity of mathematical ability affects teaching methodologies, with the teachers in this study stating that they cannot teach the way they would like or go into the depth that is required and outlined in the policy documents. They believe that many of the students who are opting to do HL mathematics, motivated primarily by the incentive of bonus points, possess the ability but require more time to fully grasp the material presented in class. This need for extended instructional time significantly slows the teacher's pace, which is often unfeasible within the constraints of the school timetable. For students who decide to switch to OL, most remain in the HL class until shortly before the exam. As a result, even though these students ultimately do not sit the HL mathematics examination, the teacher has still taught them at HL throughout the entire two-year period (Prendergast et al., 2019). This prolonged exposure to material beyond their capability can negatively affect students' confidence, as they face continual reminders of their shortcomings through regular assessments. Research conducted by Krannich et al. (2019) affirmed that when students are overchallenged, it has a negative impact on their academic self-concept. The nature of the leaving certificate examination itself does not lend itself to innovative teaching methodologies. The literature is unanimous that high-stakes assessment, especially when based on 100% final examinations at the end of schooling, negatively impacts teaching. This assessment approach often narrows the curriculum and pressures teachers to focus disproportionately on exam content, to the detriment of broader learning and instructional quality (Au, 2007; Farvis & Hay, 2020; Tóth & Csapó, 2022; Zhao et al., 2016).

The extensive nature of the HL mathematics syllabus presents a formidable challenge for teachers. As outlined previously, the curriculum is both broad and rigorous, with expectations that far exceed those of the OL. This significant disparity is often poorly understood outside of specialised teaching circles. Additionally, the tension between curriculum demands and teaching ideals creates further challenges. One of the primary aims of the leaving certificate mathematics curriculum is to foster deep mathematical understanding, promote connections between concepts and strands, and highlight real-world applications. Teachers are encouraged to make mathematics meaningful by demonstrating its relevance across disciplines and everyday life, with problem-solving intended to be woven throughout the teaching and learning process. However, the vastness of the syllabus and the limitations of available instructional time frequently compel teachers to compromise on these broader educational goals. The sheer volume of material to be covered is a challenge for teachers, many of whom report needing to teach outside their timetabled hours simply to stay on track. In a national survey of senior cycle mathematics teachers in Ireland (n = 540), 82% indicated that they did not have sufficient time to deliver the full HL syllabus, with 66% resorting to additional teaching time beyond their scheduled hours (O'Meara & Prendergast, 2017). Consequently, teachers often feel compelled to prioritise breadth over depth, resulting in a curriculum that is delivered at pace rather than with pedagogical richness. As a result, pedagogical aspirations, such as conceptual understanding, interconnectivity, and authentic problem-solving, are often sidelined in favour of simply covering the required content. Curriculum overload presents a significant challenge to teacher effectiveness, particularly in subjects where the breadth and depth of content are substantial. When teachers are required to deliver an extensive syllabus within a limited timeframe, the focus often shifts from deep, conceptual learning to surface-level coverage of material (Hattie, 2009). This time pressure can restrict opportunities for more interactive, student-centred pedagogies such as inquiry-based learning, problem-solving, and cross-strand integration–all of which are central to effective learning, especially in subjects like mathematics (Artigue & Blomhøj, 2013). Moreover, the expectation to "cover the syllabus" can lead teachers to adopt more traditional, exam-focused approaches that prioritise procedural fluency over genuine understanding. This compromises the quality of classroom engagement and limits the ability to differentiate instruction based on students' needs. As a result, students experience the subject as a rushed and disconnected series of topics, rather than as a coherent and meaningful discipline (Suprayogi et al., 2017). These findings directly address the second research question: what are the challenges teachers face when teaching advanced level mathematics?, highlighting the multiple pressures and compromises that teachers experience in practice.

Teaching-time equity emerged as another significant concern, with many teachers interviewed highlighting the considerable variation in the time allocated to mathematics instruction across different schools. Research by O'Meara and Prendergast (2017) estimated that this discrepancy can amount to as much as 122 hours over the entire senior cycle in Ireland. This issue is prevalent across many countries. TIMSS (2019) data illustrate considerable variation in instruction time across participating countries. This is significant because large disparities in time allocation leads to inequities in learning opportunities (Phelps et al., 2012). Baker et al.'s (2004) study on TIMSS (2019) data found a positive correlation between the amount of instructional time and student achievement on international assessments. Countries that allocated more time to instruction tended to have higher student performance. There is evidence that nearly half of secondary schools in Ireland begin teaching the senior cycle mathematics syllabus during TY, despite guidelines indicating that TY should not be used for this purpose (O'Meara & Prendergast, 2017; Prendergast & O'Meara, 2016). While this practice creates a markedly uneven playing field for students nationwide, it is nonetheless understandable why many schools feel compelled to adopt this approach.

The pressures experienced during examinations closely mirror those faced in teaching, with teachers noting that students often lack sufficient time to engage deeply with problems under exam conditions. Because effective problem-solving requires both time to teach and time to execute, students are unable to fully demonstrate their abilities within the constraints of the 2.5-hour exam, leading to an emphasis on speed that undermines opportunities to show true understanding. As a result, many students fall short of reaching their full potential in these high-stakes assessments which can have a substantial impact on students' academic outcomes and future prospects. The pressure to achieve strong results often elevates stress levels, which may impair students' capacity to accurately demonstrate their knowledge and understanding of the subject (Beilock, 2008; Ermatova & Sharipov, 2024). The suggestion of reintroducing choice in exam questions elicited mixed responses: some teachers welcomed the flexibility it could offer students, while others expressed concern about the potential for content omission, echoing earlier critiques of pre–project maths syllabi, where significant sections of the syllabi were omitted, thus leaving students vastly underprepared when they proceeded to university mathematics modules (Gill, 2006). Therefore, in addition to ensuring all content is covered in preparation for the examination, preparing students for the examination itself is an added challenge for teachers.

CONCLUSION

How systemic reform interacts with everyday teaching practice is a critical but underexplored aspect of educational change. This study offers a meaningful contribution to the existing body of research on HL mathematics education by providing a qualitative lens on issues that have largely been examined through quantitative methods. While previous studies by O'Meara et al. (2020) and Treacy (2017) have provided valuable large-scale data on participation trends and the broad effects of policy changes, such as the introduction of bonus points for HL mathematics on subject uptake, this study takes a different approach, one that centres on the lived experiences and professional judgements of classroom teachers, those who are tasked with delivering the curriculum under these evolving conditions.

By engaging directly with teachers through in-depth interviews, this research uncovers nuanced insights into how policy changes, in the form of bonus points for HL mathematics, are shaping classroom dynamics, pedagogical decisions, and curriculum pacing. Unlike the broad patterns identified in quantitative studies, this qualitative approach highlights the complexity and context-dependence of these changes. This qualitative study uncovers classroom-level impacts that are not easily visible through quantitative analysis. Teachers described struggling to balance increased student numbers and the resulting growing diversity of student ability levels with the demands of an extensive and challenging syllabus, often at the cost of deeper learning opportunities such as problem-solving, illustrating connections between mathematical topics, and real-world applications. Participant teachers described how this shift has affected curriculum coverage and lesson pacing.

Importantly, the findings suggest that while policy measures may succeed in raising participation, they also produce unintended consequences that may compromise the quality of teaching and learning. This contribution deepens the understanding of how system-level initiatives interact with classroom realities, something that is not easily captured through surveys or statistical analyses alone. As such, this study complements existing research by adding a layer of depth and interpretation to the field. By capturing the voices of teachers and illuminating the practical challenges they face, this study adds a new layer of interpretive insight to the field and underscores the importance of supporting teachers as they navigate the complex demands of inclusive, advanced level mathematics education.

While this study is situated within the specific context of Ireland's HL mathematics curriculum, its findings have broader relevance both internationally and across subject areas. Many education systems grapple with the dual aims of increasing student participation in advanced academic pathways and maintaining high-quality pedagogy. The Irish governments use of bonus points to incentivise the uptake of HL mathematics is one such policy, and its effects, as reported by the teachers in this study, highlight a set of challenges with cross-national significance. Participants consistently described how the influx of students, some of whom may not have the prior attainment or confidence typically associated with effective participation at this level, has had unintended consequences for teaching and learning. Specifically, teachers reported having to slow the pace of instruction and make trade-offs between covering the full syllabus and implementing best-practice methodologies such as problem-solving and exploring mathematical connections and real-world applications. These findings echo wider concerns in education literature about how systemic policies can place pressure on classroom practice, narrowing pedagogical opportunity and affecting student outcomes.

Moreover, the themes emerging from this study are not exclusive to mathematics. Similar dynamics may be observed in other subjects and countries where curricular rigour intersects with broad access initiatives. Whether in science, languages, or humanities, educators face the tension between inclusivity and depth between meeting the needs of a more diverse cohort and preserving space for critical thinking and creativity. This study, therefore, contributes to international discussions on educational policy, equity, and teaching quality. It offers a grounded example of how well-meaning, system-level reforms can trickle down to everyday classroom decisions, with implications for curriculum implementation, teacher autonomy, and student learning experiences.

In conclusion, the influence of this points incentive is very powerful and is evident well before students enter the senior cycle, as both students and their parents become attuned to its implications early in secondary education. This is reflected in the corresponding increase in participation in HL mathematics during the junior cycle (Prendergast et al., 2020). Ultimately, teachers are navigating a system that prioritises coverage over comprehension. Many teachers advocate for a reduction in syllabus content to enable more effective teaching and learning. They also express concern for students' well-being and confidence, especially those who struggle to keep pace but remain in HL classes due to the lure of bonus points. This environment risks fostering surface learning, inequitable access, and long-term challenges in mathematical progression.

Future research could extend this study by engaging a larger and more diverse group of leaving certificate HL mathematics teachers, allowing for comparisons across school types, regions, and student cohorts. Longitudinal studies would be particularly valuable in tracking how teachers' practices evolve as the profile of HL students continues to change over time, particularly if assessment practices change in the future to align better with assessment at junior cycle. In addition, incorporating student perspectives could offer important insights into how they experience the pace, pressures, and pedagogical approaches reported by teachers, highlighting possible areas of alignment or tension. Finally, combining interview data with classroom observations would provide a richer understanding of how teachers balance curriculum coverage, differentiation, and exam preparation in practice.

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Declaration of interest: The authors declared no competing interest.

Data availability: Data generated or analysed during this study are available from the authors on request.

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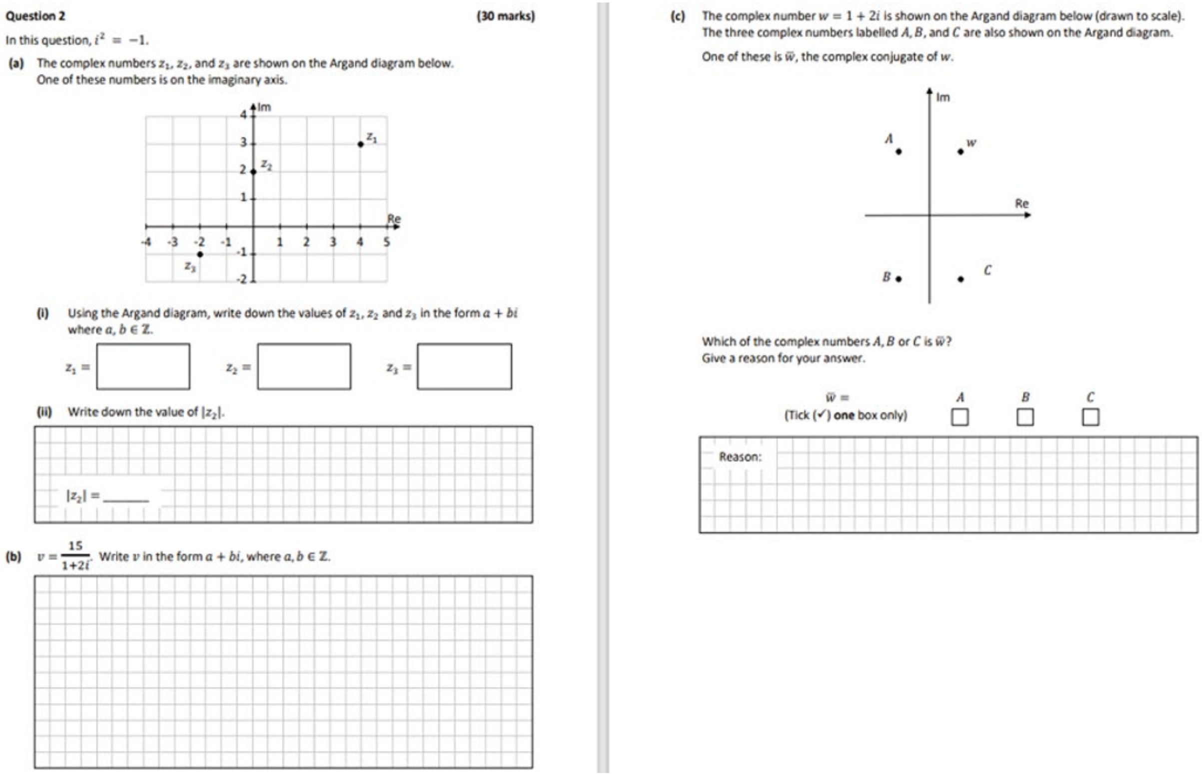
APPENDIX A


Question 2 **(30 marks)**

In this question, $i^2 = -1$.

(a) The complex numbers z_1, z_2, and z_3 are shown on the Argand diagram below. One of these numbers is on the imaginary axis.

(i) Using the Argand diagram, write down the values of z_1, z_2 and z_3 in the form $a + bi$ where $a, b \in \mathbb{Z}$.

$z_1 =$ $z_2 =$ $z_3 =$

(ii) Write down the value of $|z_2|$.

$|z_2| =$ ______

(b) $v = \frac{15}{1+2i}$. Write v in the form $a + bi$, where $a, b \in \mathbb{Z}$.

(c) The complex number $w = 1 + 2i$ is shown on the Argand diagram below (drawn to scale). The three complex numbers labelled A, B, and C are also shown on the Argand diagram.

One of these is $\bar{w}$, the complex conjugate of w.

Which of the complex numbers A, B or C is $\bar{w}$? Give a reason for your answer.

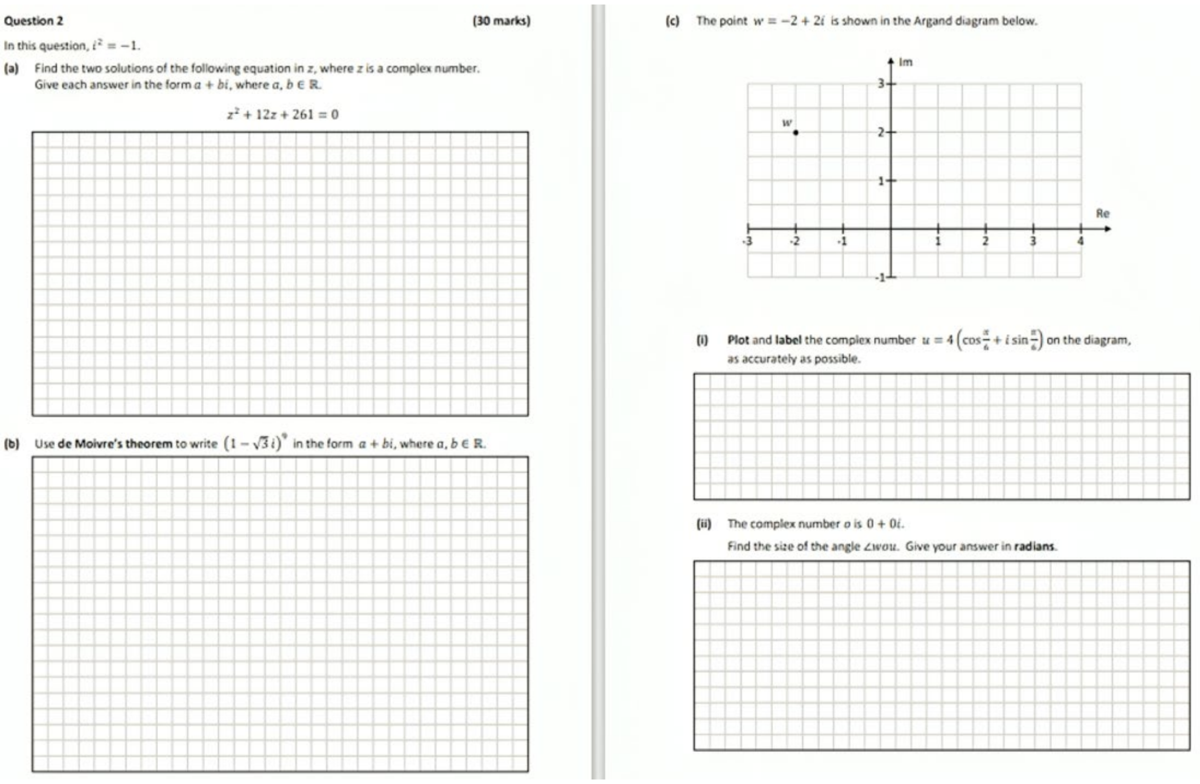
$\bar{w} =$ A B C

(Tick (✓) **one** box only)

Reason:

Figure A1. 2024 OL leaving certificate examination complex numbers question (©State Examinations Commission, 2024a; reprinted with permission)

APPENDIX B


Question 2 **(30 marks)**

In this question, $i^2 = -1$.

(a) Find the two solutions of the following equation in z, where z is a complex number. Give each answer in the form $a + bi$, where $a, b \in \mathbb{R}$.

$$z^2 + 12z + 261 = 0$$

(b) Use **de Moivre's theorem** to write $(1 - \sqrt{3}\,i)^9$ in the form $a + bi$, where $a, b \in \mathbb{R}$.

(c) The point $w = -2 + 2i$ is shown in the Argand diagram below.

(i) **Plot** and **label** the complex number $u = 4\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$ on the diagram, as accurately as possible.

(ii) The complex number o is $0 + 0i$.

Find the size of the angle $\angle wou$. Give your answer in **radians**.

Figure B1. 2024 HL leaving certificate examination complex numbers question (©State Examinations Commission, 2024b; reprinted with permission)