Society of Actuaries in Ireland

Understanding the gender gap at the highest performance level in Leaving Certificate Higher Level Mathematics

and the widening gender gap at entry level to the actuarial profession in Ireland

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Prepared by the Society of Actuaries in Ireland Gender Pipeline Working Group

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Preface

The Society of Actuaries in Ireland ("the Society") is the professional body representing the actuarial profession in Ireland. The Society's Mission includes the following:

> ***[To] Serve the public interest by promoting thought leadership and contributing as an independent voice on matters where an actuarial perspective can add value.***

In this context, the Society is pleased to present this report.

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Introduction

This paper stemmed from a concern within the Society of Actuaries in Ireland (SAI) about a decline in the proportion of female new entrants to the actuarial profession from the late 2000's, which was a reversal of a steady increase to parity in the previous decades.

The SAI was founded in 1972 and early entrants to the profession were predominantly male. From the mid-1990s onward, the proportion of female entrants began to increase steadily. Between 2001 and 2006, the numbers of males and females entering the profession were broadly equal. However, in recent years, growth in the number of female entrants has not kept pace with growth in the number of male entrants. So, the proportion of females joining has fallen steadily, to the point where just 30% of students who joined in the last two years were female.

The SAI established a Gender Pipeline Working Group ("Working Group") to examine why this decline in the proportion of female new entrants has occurred. This paper is presented by the Working Group.

What we found is that the decline in the proportion of female new entrants to the profession broadly mirrors a gender gap at the highest performance level in Leaving Certificate Higher Level Mathematics which has been particularly evident since 2012.

This gender performance gap is not just a very concerning issue for the actuarial profession in Ireland but is also likely to have implications at a wider society level in terms of gender imbalance in STEM (**S**cience, **T**echnology, **E**ngineering and **M**athematics) careers and female access to high-points third level courses generally.

Project Maths

The sharp decline in female performance at the highest attainment level in 2012 coincided with the introduction of two material changes to Leaving Certificate Higher-Level Mathematics:

I. 2012 was the first year that the new "Project Maths" syllabus was examined. There were some changes to the syllabus as a result of Project Maths, but the key change we believe that contributed most to the widening of the gender gap for the highest achievers was the introduction of "unseen" application questions.

II. It was also the year that an additional 25 flat bonus points were introduced for all students who achieve a H6 (mark of 40% to 49%) or above in Higher Level Maths.

"Project Maths" is the name given to the mathematics syllabus which has been taught in secondary schools in Ireland since 2010. Project Maths places more emphasis on real-life scenarios with the objective of giving students a real understanding of mathematics, as opposed to knowledge gained through a more abstract and procedural approach (Department of Education and Skills, 2015). From an industry perspective, the emphasis on applying mathematics to real life situations, such as the inclusion of Financial Mathematics and practical statistical questions, is certainly a positive development.

However, research (Roche, et al., 2019) has established that the application style questions introduced to the Leaving Cert. examination as part of the Project Maths syllabus changes require not just mathematical skills but also the application of spatial reasoning as there is a proven link between spatial ability and problem-solving ability. Spatial reasoning has been proven to reduce working memory load and increase success in solving mathematical "word problems". The research also points

to an internationally recognised gender gap in spatial reasoning. This gender gap in spatial reasoning is also known to widen through the secondary school years. We believe therefore that the introduction of these "unseen" questions that require spatial reasoning skills to the Leaving Cert. examination has significantly discriminated against our female Leaving Cert. students. We believe this to be a key driver of the widening gender gap that coincided with the introduction of Project Maths.

Research in Ireland has also found that teenage girls are generally less confident than teenage boys when it comes to mathematics (O'Rourke & Prendergast, 2021). The consensus among the mathematics teachers and academics we interviewed was that this confidence barrier can be breached through coaching. In Ireland, female second-level students are much less likely than males to choose subjects which hone spatial reasoning skills such as Applied Maths, Physics and Design & Communication Graphics ("DCG")[2]. Indeed, many single-sex girls' schools do not offer these more spatially focused, optional subjects. These subjects are directly beneficial to a student's ability to perform well in the application style questions in the Leaving Cert Maths exam, and the fact that many females do not have the opportunity to access them is a clear form of gender-based discrimination.

A more student-centred teaching approach was advocated with the introduction of Project Maths, placing greater emphasis on investigative learning in realistic or applied contexts (Department of Education and Skills, 2015). However, a recent study suggests that teachers have struggled to adopt the recommended changes in teaching practices, with time constraints cited as the main barrier to change. Some teachers described having difficulty completing the syllabus due to a radical shift in the ability profile of a typical Higher-Level Mathematics class which is linked to the flat bonus points system. It is possible that the restriction on teachers' scope to complete the syllabus and adopt a more student-centred teaching approach (Berry, et al., 2022) may be disadvantaging high-achieving females to a greater degree than high-achieving males.

"Female participation rate" illustrated in Figure 1 below means the percentage of students sitting Higher Level Maths who were female. Figure 1 shows that a gradual decline in relative female performance at the highest grade in Leaving Certificate Higher Level Mathematics has been evident since 2002. However, a sharp drop in female performance occurred in 2012, the first year the new Project Maths syllabus was examined.

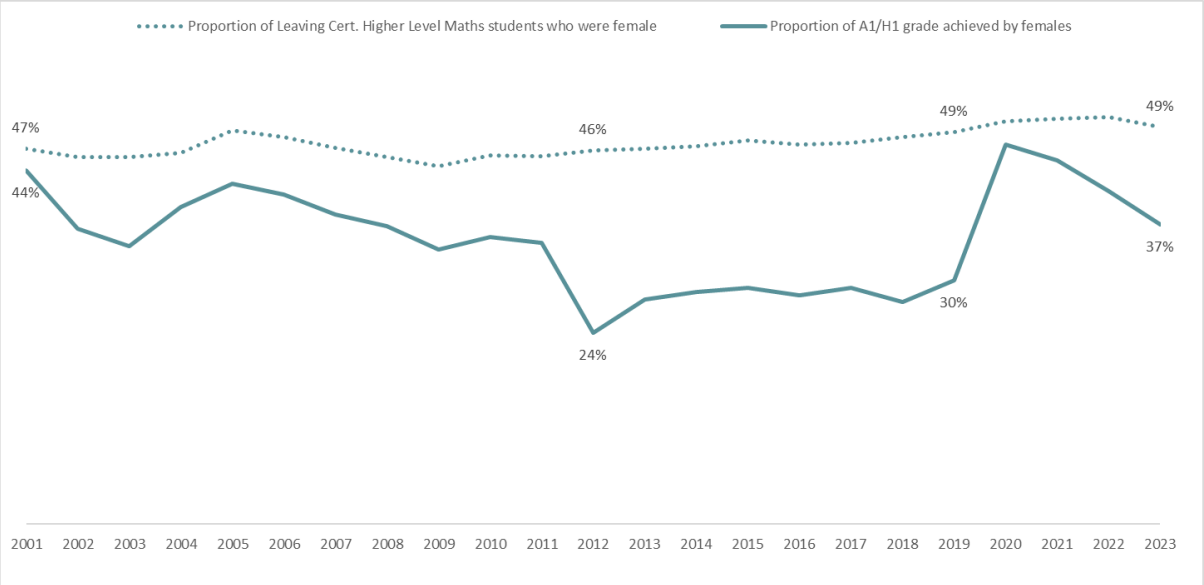

Figure 1: Leaving Certificate Higher Level Mathematics – female performance at the highest attainment grade (2001 -2023)

Males subsequently outperformed females at the highest grade in Higher Level Mathematics for the remainder of the decade, such that even though the numbers of males and females sitting the exam were broadly equal over this period, only 25% to 30% of the H1s were achieved by females, The gap broadly disappeared in 2020 when 'Calculated Grades' were introduced as a Covid-19 emergency measure. The return to an examination-based system has resulted in a gender gap re-emerging.

In another very concerning development, there was a sharp deterioration in female performance at the highest grade in the 2022 Junior Cycle Mathematics examination. The Junior Cert. Maths exam was replaced by the new Junior Cycle exam in 2022. Although the mathematical content of Junior Cycle Maths was broadly unchanged, it did involve a different approach to teaching, learning and assessment. 2022 also marked the introduction of a new grading system at Junior Cycle level.

Recommendations for the Department of Education

We have divided our recommendations into two parts - primary and secondary recommendations. The primary recommendations directly address the changes that occurred as a result of the introduction of Project Maths, the timing of which was strongly correlated with the widening of the gender gap. Critically, we also believe that some of these changes are a key driver of the widening of the gender gap.

a) Primary Recommendations

The gender gap at the highest attainment level for Higher Level Mathematics in Ireland, at Leaving Certificate level and more recently at Junior Cycle level, is extremely concerning.

i. ***We strongly recommend that an academic review of the approach to examining the Project Maths syllabus is undertaken with respect to the introduction of unseen "context and application" style questions where spatial reasoning confers an advantage, to assess their impact on the widening gender gap.***

ii. *As part of this review,* ***we recommend the investigation of Leaving Certificate Higher Level Mathematics performance by gender by question, to see if the widening gender gap has been driven by specific question types introduced as part of the Project Maths syllabus.***

iii. ***We recommend that females must be given equal opportunity to access subjects such as Applied Maths and Physics in schools that do not currently offer these subjects, because of their direct impact on improving performance in the Leaving Cert Maths applied questions****. Additionally, greater efforts need to be made to encourage females to consider choosing these subjects where they are currently available. If this is not possible, the inclusion of questions of this style on the Leaving Cert Maths exam must be seriously reconsidered on the grounds of fairness and gender discrimination.*

iv. *We strongly recommend that a review of the approach to preparing female students for the Project Maths exam is undertaken. The gender gap for Leaving Certificate Higher Level Mathematics at the highest attainment level since 2012 has been much wider than the corresponding gender gap for A-Level Mathematics in England.* ***We believe that a comparison of the teaching and examination approaches in both jurisdictions would be helpful in terms of understanding the drivers behind the wider gender gap observed in Ireland.***

We are also conscious that the introduction of 25 bonus points for all those achieving a mark of 40% or more in Higher Level Maths coincided with a significant increase with the numbers sitting Higher Level Maths, and the widening of the gender gap (though we are not suggesting this is a cause). Feedback from our discussions with a number of teachers suggests that this has, in turn, led to teachers spending much more of their time with the weaker students who were struggling to attain the 40% mark. Understandably, this has then resulted in less time being spent on the higher performing students.

v. ***We recommend that the current teaching resources allocated to Leaving Cert. Higher Level Mathematics be reviewed in light of the larger class sizes and wider range of abilities present since the introduction of the flat bonus points system.***

vi. *Finally,* ***we recommend that the results of all the above investigations (including this report) be presented to the Minister for Education and that on publication an information event be organised to discuss the findings with stakeholders.***

b) *Secondary Recommendations*

i. *The relatively high number of out of field Mathematics teachers in Irish schools relative to other jurisdictions should be addressed.*

ii. *We recommend that a separate analysis of performance by gender for single-sex and mixed schools is undertaken, which would be very helpful in terms of understanding whether the gender gap is influenced by the gender profile of learning environments.*

iii. *We recommend that a comparison of the gender gap for unadjusted grades and adjusted grades in recent years is undertaken, which we believe would also be very helpful in terms of understanding the impact of post-marking adjustments and the likely impact of the future cessation of this practice.*

Recommendations for the Society of Actuaries in Ireland

A third of the SAI's current members are female. Surprisingly, female representation is lower among student members than qualified members. The proportion of new entrants to Mathematics and Statistics undergraduate courses in the Republic of Ireland from 2016 to 2021 is broadly consistent with the current female proportion of SAI student members (c.30%). However, over half of new entrants to the accounting profession in Ireland are now female. This difference is striking given that both professions are associated with the area of finance and with numerical ability.

Student self-belief, prevalence of role models and views of parents have all been found to be key influential factors in terms of Mathematics related career choices. An ESRI report in 2019 also established that boys and girls in Ireland use different decision-making strategies when deciding whether to choose STEM third level courses. Boys tend to look at their individual comparative advantage in Mathematics relative to English while girls are more likely to decide solely based on their Mathematics ability. The differing approach to career choice is particularly relevant in an Irish context where boys consistently outperform girls at Leaving Certificate Higher Level Mathematics and girls consistently outperform boys at Leaving Certificate Higher Level English (ESRI, 2019).

Gender stereotypes relating to mathematics are prevalent in Irish society. To increase the female representation in mathematics-based careers such as the actuarial profession, urgent action must be taken to challenge existing stereotypes. A lack of female role models has been cited as one of the factors contributing to the gender gap in Mathematics based careers. **We recommend that the SAI actively markets the actuarial profession to young females, as well as their parents and teachers, using female role models.**

Research has demonstrated that females are more likely than males to seek out a career which they perceive as being meaningful[1,2] and that females are more likely than males to place more importance on work-life balance than males. **We recommend that the Society showcase the many and varied ways in which actuaries have made positive contributions to wider society in the past and can help solve future societal challenges. Flexible working environments which give rise to a more positive work-life balance are now commonplace within the actuarial profession and it is very important that young females are aware of this**.

We also **recommend that the SAI consider developing initiatives to support second-level students such as expanding the reach of the existing Maths Tutorial programme and making pre-recorded maths lessons freely available to all students.**

[1] Tiger Recruitment research: Meaningful work more important to women (tiger-recruitment.com)
[2] women-in-tech-report.pdf (pwc.co.uk)

1. Introduction

The Society of Actuaries in Ireland was founded in 1972 and early new entrants to the profession were predominantly male. From the mid-1990s onward, the proportion of female entrants began to increase steadily. Between 2001 and 2006, the numbers of males and females entering the profession were broadly equal. This is consistent with our current membership profile, whereby females comprise almost half of members who are now qualified between 10 and 15 years. However, the proportion of females joining the profession has fallen steadily in recent years, to the point where just 30% of students who joined the profession in the last two years were female.

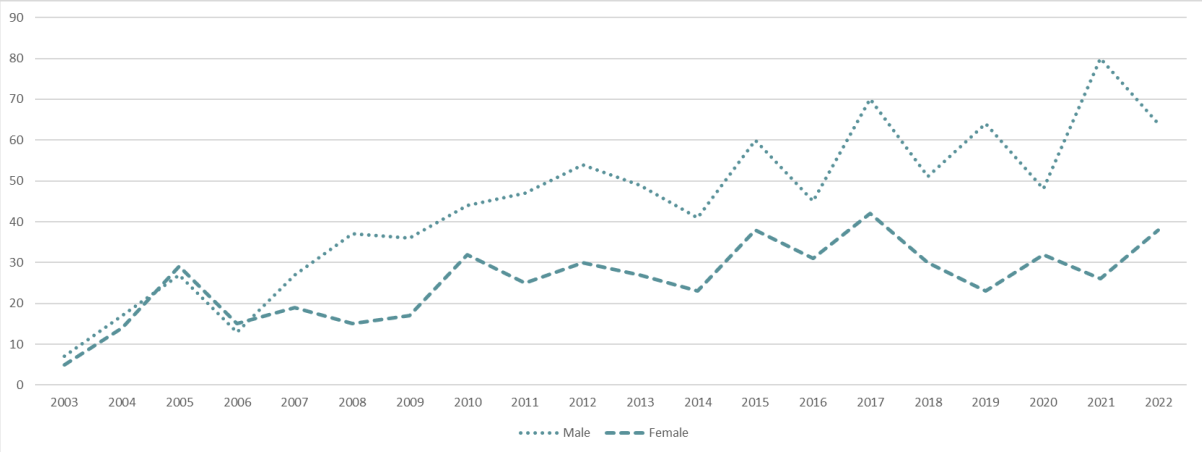

Figure 2: Number of new SAI members by year: 2003-2022

Figure 2 above shows that the total number of new entrants to the profession has increased steadily over the two decades up to 2022. However, it is also evident that the gender gap between male and female new entrants has widened significantly over that period. The marked decline in the proportion of female new entrants to the profession prompted the establishment of a Gender Pipeline Working Group in March 2022. The objectives of this Working Group were to gain insights into the drivers behind the decline and to recommend actions to reverse the decline.

SAI Gender Profile

The profile of the Society's membership in June 2023 is illustrated in Figure 3 overleaf. "Q" stands for qualified. This chart shows that just 18% of female members who are qualified more than 20 years are female. The proportion of female members peaks at just under 50% for those members who are qualified between 10 and 15 years, before falling again for members who qualified within the last 10 years. The female proportion of our current student body is lower again at 30%.

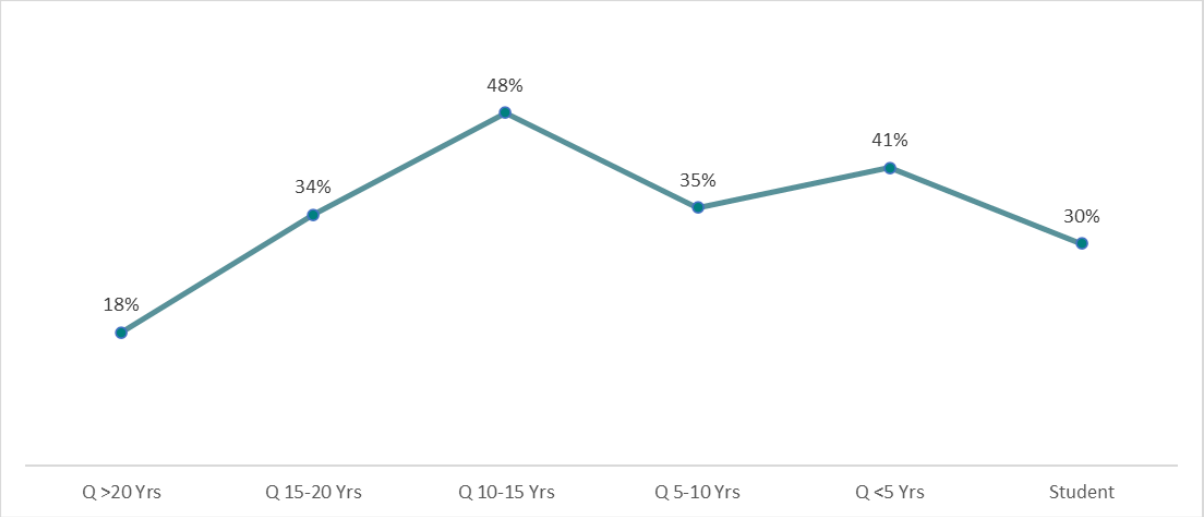

Figure 3: SAI female representation at student and qualified level (2023)

The gender profile of the Society's current student body is broadly consistent with that of the undergraduate actuarial degree courses in the Republic of Ireland over the past decade. Further information on the gender profile of undergraduate actuarial degree courses is provided in Section 2 of this report. The marked decline in the proportion of female new entrants to the profession broadly mirrors the decline in female performance at the highest grade in Leaving Cert Higher Level Mathematics. While a gradual decline in female performance is evident since 2002, the gender gap widened significantly in 2012. This issue is examined further in Section 4 and Section 5 of this report.

Females represent a third of the current membership of the Society of Actuaries in Ireland. The SAI has a higher female representation than Engineers Ireland where 12% of members are female[3]. However, the SAI has a lower proportion of female members than both the accounting and legal professions in Ireland, which stood at 44% and 53% respectively in 2022[4].

The SAI is an outlier relative to other professional bodies in that it has a lower proportion of female students than female qualified members. This is at odds with our counterparts in the Institute and Faculty of Actuaries UK (IFoA) and the Actuarial Society of South Africa. As of August 2023, females represented 30% of the overall IFoA membership[5]. The overall female IFoA representation is thus slightly lower than the current overall SAI female representation of 33%. However, 43% of IFoA student members are female, which is significantly higher than the SAI's 30% female student representation. It is also worth noting that the IFoA's 43% female representation at student level is broadly in line with the proportion of females who sit A-Level Mathematics in England[6]. Data provided by the Actuarial Society of South Africa showed the female proportion of new members increasing steadily from 30% in 2010 to 48% in 2018.

[3] More must be done to stem loss of female engineers from industry, according to Engineers Ireland - Engineers Ireland

[4] Profile of the Profession 2022 - IAASA

[5] Source: Institute and Faculty of Actuaries (August 2023)

[6] A level outcomes in England (ofqual.gov.uk)

The SAI membership profile is also at odds with that of the legal profession in Ireland[7] and IAASA[8] (the Irish Auditing and Accounting Supervisory Authority which is the umbrella body for the Irish accountancy professional bodies) and Engineers Ireland[9]. While overall female membership rates across these bodies vary, they all have a higher proportion of females at student relative to qualified level.

The gender gap at entry level to the actuarial profession relative to the accountancy profession in Ireland is particularly striking. Just 30% of current SAI students are female, compared to 52% of student members of the accountancy bodies in Ireland. The size of this gap is noteworthy given that both professions are associated with the area of finance and with numerical ability

[7] Pathways to the Profession 2022 (lsra.ie)
[8] Profile of the Profession 2022 - IAASA
[9] Source: Engineers Ireland (2022)

2. Leaving Certificate Higher Level Mathematics Performance

The actuarial profession tends to attract students with both a high level of mathematical ability and a passion for mathematics. It is very common for those who choose to pursue an actuarial career to have attained a very high mathematics grade in their final second-level exams. We have observed that the decline in the proportion of female new entrants to the actuarial profession in Ireland in recent decades has broadly mirrored the decline in the female proportion of Leaving Certificate students attaining the highest grade in the Higher-Level Mathematics exam since 2002.

Widening gender gap

The State Examinations Commission have published Leaving Certificate results data by gender for all subjects from 2001 onwards[10]. The highest attainment grade[11] over this period equated to an examination result of 90% or above. Figure 4 below describes the female participation rate for Higher Level Mathematics and the percentage of the highest attainment grade awarded to females each year from 2001 to 2023.

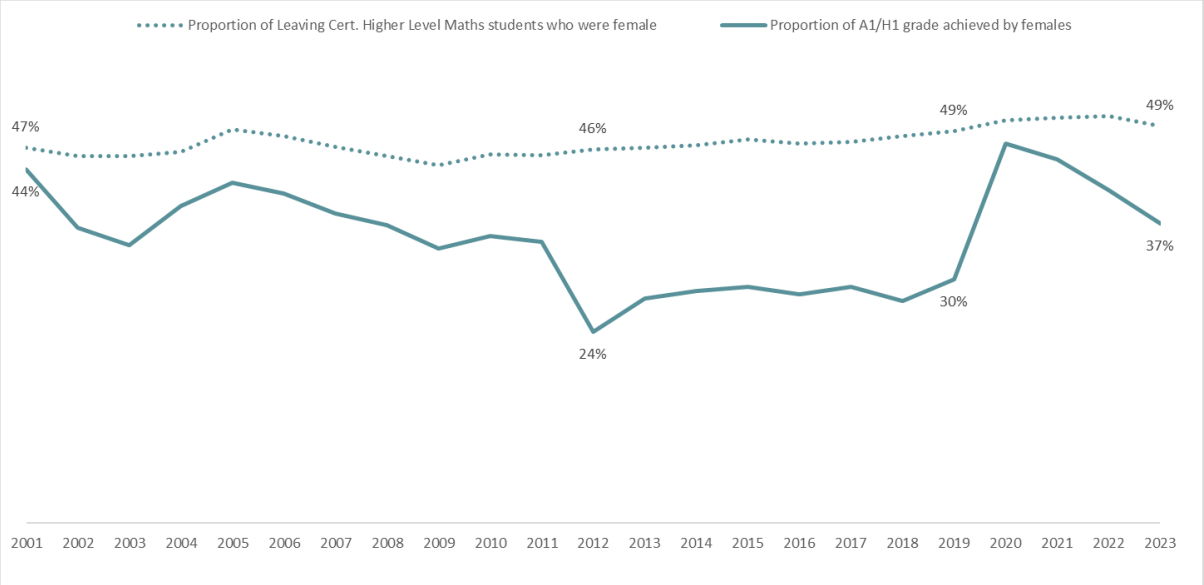

Figure 4: Leaving Certificate Higher Level Maths (2001-2023): Female participation rate v proportion of A1/H1 grades awarded to females

44% of students who were awarded the highest attainment grade in 2001 were female. This was very close to the overall female participation rate for Higher-level Mathematics that year of 47%. Although a gradual decline in relative female performance at the highest grade has been evident since 2002, a sharp drop occurred in 2012. Males subsequently outperformed females at the highest grade in Higher Level Mathematics for the remainder of the decade, such that even though the numbers of males and females sitting the exam were broadly equal over this period, only 25% to 30% of the H1s were achieved by females, The gap broadly disappeared in 2020 when 'Calculated Grades' were introduced as a Covid-19 emergency measure. The return to an examination-based system has resulted in a gender gap re-emerging.

[10] Annual Exam Statistics - State Examination Commission (examinations.ie)
[11] A1 between 2001 and 2016, H1 since 2017

Analysis undertaken by the winners of the SAI 2022 Student Competition[12] found that the large gender gap in favour of males for Leaving Cert Higher Level Mathematics since 2012 was inconsistent with experience across other science subjects, including Physics. The 2019 ESRI report also stated the largest performance advantage in science subjects for females over the period 2015 to 2017 was in fact for Physics (ESRI, 2019). Based on an analysis of academic performance across Mathematics and Statistics courses across five Irish universities from 2012 to 2017, the winners of the SAI 2022 Student Competition also established that females were more likely than males to obtain a first-class honours degree[13].

Impact of Covid-19 emergency responses

Ireland's emergency solutions – the Calculated Grades System in 2020 and the Accredited Grades System in 2021 – gave students the option to draw on teachers' professional judgement to estimate their grades. Students were offered the option of receiving Calculated Grades for the subjects they were studying based on their teachers' professional judgement, with the opportunity to sit the 2020 Leaving Certificate examinations in November of that year. In such cases, they were accorded the better result on a subject-by-subject basis. In 2021, as the Covid-19 pandemic continued, a set of Leaving Certificate examinations took place in June. Leaving Certificate candidates could also opt for a set of Accredited Grades through a system operated by the State Examinations Commission (SEC), known as SEC-Accredited Grades. In this way, students could opt for written examinations, SEC-Accredited Grades or a combination of the two. Again, they were accorded the better result on a subject-by-subject basis[14].

Specific decisions were made to ensure that no group of students was disadvantaged by either the Calculated or Accredited Grades Systems. Although it was acknowledged that demographic characteristics, such as a student's gender or their socio-economic background in cross-national contexts, are known to correlate with test scores, these were not factored into the estimation model. This meant that an individual student's Calculated Grade would not be directly influenced by factors such as the student's gender. It has been suggested that higher proportion of H1s awarded to females in 2020 and 2021 (relative to pre-pandemic years) was due to unconscious estimation bias which generally favours female students[15].

Figure 5 overleaf illustrates the percentage of the overall Leaving Cert population[16] of male and female students achieving a H1 in Higher Level Mathematics each year from 2011 to 2023. The grade inflation introduced following the emergency Covid-19 measures is evident. Although the H1 grade inflation in Higher Level Mathematics did reduce somewhat in 2023, overall attainment rates for males and females were significantly above pre-2020 levels. Interestingly, there has been an increase in the percentage of Leaving Certificate students achieving the highest H1 grade in Higher Level Maths during this exceptional period since 2019. Previously, less than 3% of male LC students and just over 1% of females achieved the highest grade in Higher Level Maths. Given the impact of grade inflation, females were twice as likely to achieve a H1 grade in the 2023 Leaving Certificate examination than in 2019. However, the increase in the number of males achieving a H1 grade in 2023 compared with pre-pandemic years was higher than for females, even allowing for any difference in the total number of students sitting Leaving Cert Higher Level Maths.

[12] STEMinism – Women in Maths - Kate Corcoran, Emily Walsh & Joseph Wetz (2022)
[13] STEMinism report produced by the winners of the 2022 SAI Student Competition
[14] Implementation of Ireland's Leaving Certificate 2020-2021: Lessons from the COVID-19 Pandemic (oecd-ilibrary.org)
[15] Calculated Grades for Leaving Certificate 2020 - Report from the National Standardisation Group (Dept. of Education & Skills)
[16] Sum of students sitting Higher Level, Ordinary Level and Foundation Level Mathematics

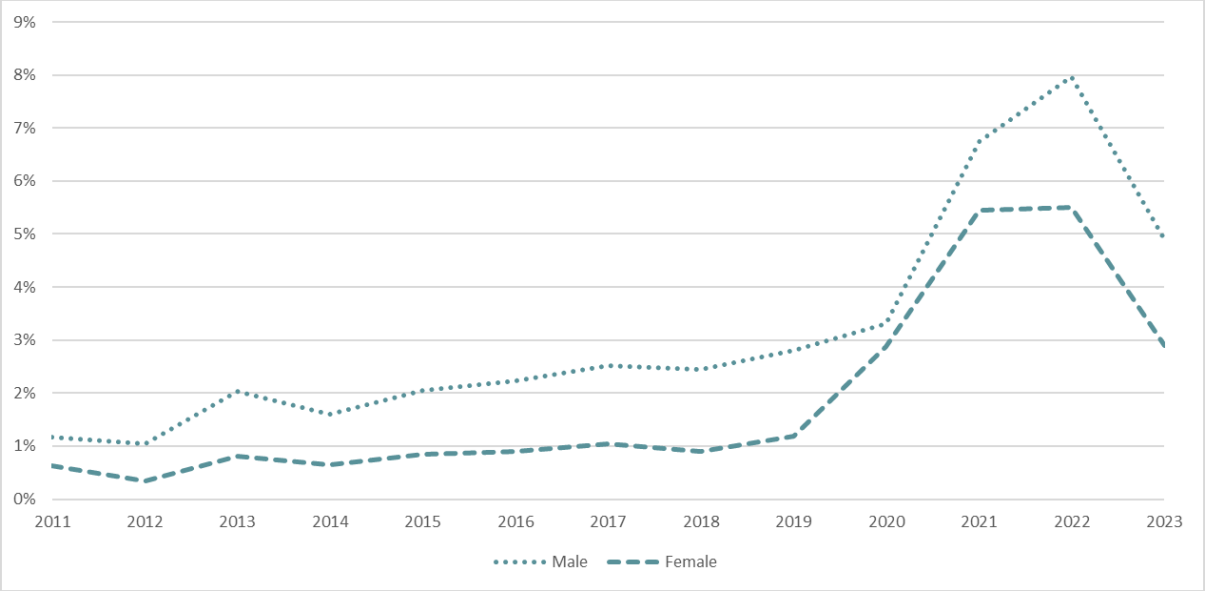

Figure 5: Leaving Cert. Higher Level Maths (2011-2023) – Percentage of the overall Leaving Certificate male and female student populations achieving the highest attainment grade

An OECD report[17], commissioned in 2023 by the Department of Education, highlighted how the CAO points system is unusual in that it is "particularly competitive" and "every single mark can be critical" for entry into college. This report concluded that grade inflation needs to be controlled to protect the integrity of the exam.

International comparison

Research has identified a gender gap in the mathematical attainment of post-primary students around the world, favouring male students[18] (Roche, et al., 2019) (Bahar, 2021). It has also been found that boys are more represented in both the top and bottom tails of the ability distribution (ESRI, 2019). However, an analysis of scores in Advanced Placement Mathematics in the US between 1997 and 2019 showed that although the gender disparity among top achievers remains substantial, this gender gap has been slowly narrowing over time (Bahar, 2021). The Working Group also found that the gender gap favouring males at the highest attainment level for A-Level Mathematics in England has generally been much narrower than the corresponding gender gap for Leaving Certificate Higher Level Mathematics in Ireland.

The A* grade under the UK A-Level exam system is consistent with the Leaving Certificate A1/H1 grade. The Working Group analysed publicly available A-Level Mathematics results in England over the period 2018 to 2023. As illustrated by Figure 6 overleaf, the female participation rates for Leaving Cert Higher Level Maths and A-Level Maths have diverged over the past decade. The improvement in the female participation rate for Leaving Cert Higher Level Mathematics from 46% to 49% is likely to have been influenced by the flat bonus points system introduced in 2012.

[17] Implementation of Ireland's Leaving Certificate 2020-2021: Lessons from the COVID-19 Pandemic | en | OECD

[18] Girls still fall behind boys in top scores for AP math exams (theconversation.com)

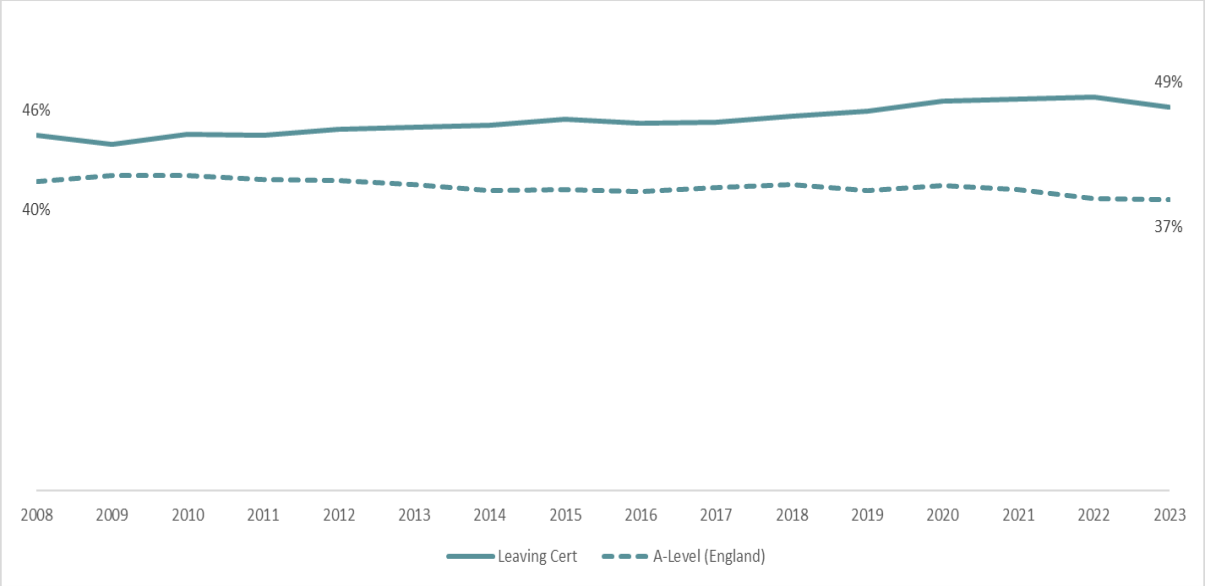

Figure 6: Leaving Cert Higher Level Maths v A-Level Maths England - Female Participation Rate (2008-2023)

A small gender gap in favour of males at the highest attainment grade in Mathematics is evident from the A-Level statistics. However, Figure 7 illustrates that the Leaving Certificate gender gap at the highest attainment grade has generally been much wider. It is also evident that the impact of Covid related measures implemented since 2020 on the gender gap were more pronounced for Leaving Cert Higher Level Mathematics than for A-Level Mathematics.

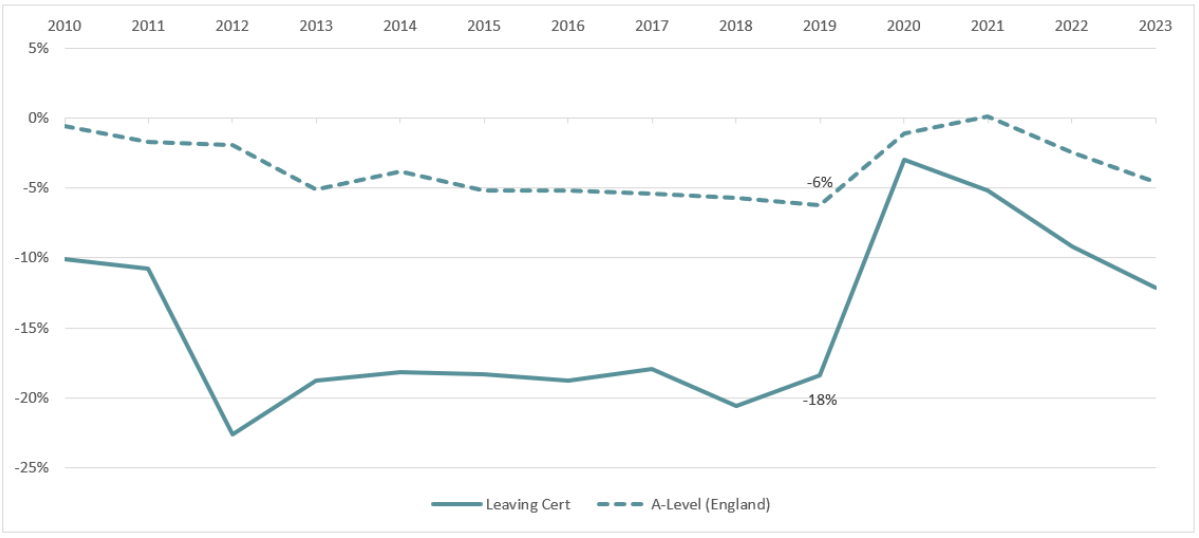

Figure 7: Leaving Cert Higher Level Maths v A-Level England Maths - Difference between the proportion of students who were female and the proportion of highest attainment grade awarded to females

Looking at figures 6 and 7 together, it can be seen that in 2019, 39% of those sitting A-Level Maths in England were female, with 33% of the A* grades awarded to females that year (leading to a gap of 6% between participation rate and proportion achieving highest grade). By sharp contrast, in the same year, 48% of those sitting Higher Level Leaving Certificate Mathematics in Ireland were female but only 30% of the H1 grades were achieved by females that year (leading to a gap of 18% between participation rate and proportion achieving highest grade)

Our Working Group surveyed 204 actuarial undergraduate degree students in UCD[19], DCU[20], UCC[21] and QUB[22] during the academic year 2022/2023. Respondents were broadly spread across the four universities and entry years. 37% of those who completed the survey were female. The survey responses were considered representative of the overall population of students in terms of both the number of responses and the gender profile of respondents. Male respondents were much more likely h6to have achieved a H1 grade in Leaving Certificate Higher Level Mathematics than females. Of those who provided Leaving Certificate Higher Level Mathematics results, 90% of males achieved a H1 grade, compared with two thirds of females. Amongst the survey respondents, males were thus a third more likely to have achieved a H1 grade in Leaving Cert Higher Level Mathematics than females. The gender gap observed in respect of the highest attainment grade in Leaving Cert Higher Level Mathematics among the survey respondents is particularly noteworthy, given that males and females who provided A-Level Mathematics results were equally likely to have achieved an A* grade.

In conclusion, over the last 20 years we have observed a much narrower gender gap for the highest performing mathematical students in England and a narrowing of the gender gap in the US. In sharp contrast, this gender gap has noticeably widened in Ireland since the introduction of Project Maths. The English and US mathematical education systems are succeeding in maintaining a narrower gender gap and reducing the gender gap respectively.

[19] University College Dublin
[20] Dublin City University
[21] University College Cork
[22] Queen's University Belfast

3. Project Maths

The sharp drop in female performance in 2012 coincided with the introduction of two material changes to Leaving Certificate Higher-Level Mathematics. 2012 was the first year that the new "Project Maths" syllabus was examined. It was the also the year that an additional 25 flat bonus points were introduced for all students who achieve a grade of H6 or above in Higher Level Maths (i.e., a mark of over 40%).

Background

Mathematics education in Ireland has undergone significant reform in the past twelve years, with a major initiative, "Project Maths," introducing a reformed curriculum initially to 24 schools from 2008 and then nationally from 2010. The changes were phased in over three years concurrently at Junior and Senior Cycle. This was the first comprehensive curriculum reform in post-primary Mathematics for over 50 years, aiming to change not only the content, which had evolved incrementally over the period, but also both teachers' and students' approaches to mathematics. Project Maths was an attempt to modernise a perceived outdated curriculum by simultaneously altering the content of the curriculum, teaching methodologies, and the national assessment strategies. This reflected a belief by policymakers that only by altering all three of these curricular pillars simultaneously could they definitively remove the prevailing approach of 'teaching to the test' (Johnson, et al., 2019). Project Maths emphasised the development of problem-solving competency in both familiar and unfamiliar contexts, via a more student-centred approach. The overall aim of Projects Maths was to teach mathematics in a way which leads to real understanding. Project Maths places more emphasis on real-life scenarios and requires a real understanding of mathematics as opposed to knowledge gained through a more abstract and procedural approach. The Project Maths curriculum promotes teaching mathematics in a social context, with a focus on flexibility, creativity, problem-solving, and links within mathematics and between other subjects (Department of Education and Skills, 2015). Project Maths was examined for the first time at Leaving Cert. level in 2012.

From an industry perspective, the emphasis on applying maths to real life situations, such as the inclusion of Financial Maths and practical statistical questions is certainly a positive development. The new examination became far less predictable than the 'old' papers as more questions required solving problems in unfamiliar contexts. Also, topics that would have previously been contained in stand-alone questions are now interconnected in expansive, layered questions (Roche, et al., 2019).

The reception to the new Project Maths curriculum has been mixed, with supporters of the syllabus saying it engages students more and helps them to learn Maths and apply it in real-life situations. In an Irish Times article from 2017, Aidan Roantree (Senior Maths Teacher at the Institute of Education) expressed the view that students are better prepared to diagnose questions and determine an appropriate approach for solving them but are not nearly as well prepared as before to execute their correct diagnosis due to inferior and inadequate skills in basic algebra[23].

Gendered Approach to Problem-Solving

Research has shown that females are more cautious than males when it comes to tackling unseen problems. The Women and Public Policy Program's Gender Action Portal (GAP) at Harvard Kennedy Business School found that in a competitive test-taking environment with penalties for wrong answers, women are less willing to guess, resulting in a loss of potential points and lower scores compared with male test-takers[24]. It has also been established that teenage girls are generally less

[23] Project Maths: Or is it just Maths? – The Irish Times

[24] Gender Differences in Willingness to Guess | Gender Action Portal (harvard.edu)

confident than teenage boys when it comes to mathematics and it has been shown that girls tend to perform worse than males in applied problem-solving scenarios, as opposed to computational procedures. It has been found that in some cases, girls are inclined to move towards familiar routes in tackling difficult mathematical problems, instead of attempting techniques which may not be immediately obvious (O'Rourke & Prendergast, 2021). Teachers we interviewed spoke of girls being more likely than boys to want to be ultra-prepared for exams, a factor which may ironically be hindering girls' performance in the Leaving Certificate Higher Level Mathematics exam.

Research published on Irish post primary students' attitudes to mathematics in 2021 found that girls had much lower confidence than boys in their problem-solving abilities. As such, despite feeling similar levels of support in the classroom, girls not only seemed to enjoy mathematics less than boys, but they also had decidedly lower levels of self-concept. At primary school level, Irish girls in both second and sixth classes in NAMER 14[25] were found to have significantly lower mean scores than boys on the Measures content area (which includes several problems) and on the "apply and problem solve" process skill. Girls also scored less well than boys on a measure of mathematical self-concept. In TIMSS[26] 2015, while fourth-class boys in Ireland significantly outperformed girls on Geometric Shapes and Measures, there were no significant gender differences across the three cognitive domains, "knowing", "applying" and "reasoning". Alongside this the Growing up in Ireland (GUI) study has produced some pertinent findings on the transition from primary to second-level education. In particular, maths test scores and attitudes to maths at the age of nine were predictive of engagement with the subject in later years (Dooley, 2019).

Researchers from the University of Chicago, the University of Rochester, and Carnegie Mellon found no significant gender differences in the neural processes of mathematics between males and females in young children. Using magnetic resonance imaging they found that mathematical processes engage the same neural networks of the brain, regardless of gender, during the critical years of cognitive development. This finding suggests that the gender gap in female mathematical performance is thus likely to be due to lower female mathematical self-belief (Kersey, et al., 2019). The consensus among the mathematics teachers and academics we interviewed was that the female mathematical confidence barrier can be breached through coaching.

Spatial Reasoning and Subject Choice

In 2019, research was undertaken into the widening gender gap at the highest attainment level in Higher Level Maths since 2012 by Dr. Aidan Roche (TUD), Dr. Gavin Duffy (TUD) and Dr. Aoibhinn Ní Shúilleabháin (UCD). They observed that problem-solving appears to be the pivotal driver of the widening gender gap. A link between spatial ability and problem-solving ability has been proven and the authors suggested that cognitive differences in spatial ability between male and female students may be contributing to the gender gap for high-achieving students in Ireland. They concluded that the development of females' spatial ability may help to address the gender gap and enable students to reach their full mathematical potential.

Students with high levels of spatial ability tend to be much more adept at mentally representing word problems in mathematics which leads to significantly higher success rates in problem solving. Early-stage research in Ireland suggests that this spatial ability gap widens as students move through post primary school. It has been proven that spatial ability can be developed through spatial skills training and exposure to spatially rich learning experiences in subjects including mathematics. Research on spatial skills has demonstrated that exposure to subjects that stimulate spatial thinking result in indirect but long-lasting skills in mental rotation, a commonly assessed aspect of spatial ability (Roche, et al., 2019).

[25] National Assessments of Mathematics and English Reading 2014
[26] Trends in International Mathematics and Science Study

Both the PISA[27] 2012 and TIMSS 2015 results indicate that the gender gap disadvantaging Irish female students at advanced levels of mathematics is larger than average. However, the gender gap at advanced levels of mathematics is less pronounced in countries that facilitate more geometry and seem to give greater support for problem solving in their classrooms. It has been proven that gender differences in mental rotation skills can disappear if females have the opportunity engage with spatial tasks and are frequently exposed to spatial thinking (Roche, et al., 2019). In Ireland, female second-level students are much less likely than males to choose subjects which hone spatial reasoning skills such as Applied Maths, Physics and DCG. Females are more likely to study Languages, Art, Music, and Home Economics. Within STEM, males are three times more likely to study Physics and Applied Mathematics while females are more likely to study Chemistry and Biology. Many single-sex girls' schools do not offer the more spatially focussed subjects. A quarter of all Junior Cert students between 2016 and 2019 studied Technical Graphics but male students were five times more likely to study this subject than females[28]. However, it has been found that similar gender differences exist in both mixed-gender and single-sex schools, where subject availability is the same for both girls and boys. Subject choices may reflect underlying preferences for STEM-type subjects, the influence of teachers, peers, or parents, or may reflect comparative advantage with students of each gender choosing subjects in which they believe they will do well (ESRI, 2019).

The 2019 ESRI report investigating gender differences in STEM career choices found that, of the portion of the gender gap in STEM third level courses that could be explained, subject choices for Leaving Certificate were the most important determinant. While this may partly reflect a difference in availability of subjects between girls' and boys' schools, their finding of similar subject choice differences in mixed-gender schools (and a larger STEM gender gap in mixed-gender schools) suggests that availability of subjects is not the only consideration. In both single sex and mixed schools, boys were much more likely to choose physics, design graphics, engineering, building construction, and applied mathematics, subjects that are strongly predictive of later doing STEM in college. Even two years before college entry, there were systematic gender differences in decision-making that led to boys being more likely to choose STEM subjects. This report recommends that policy interventions to reduce the STEM gender gap would need to be implemented when students are choosing Leaving Certificate subjects rather than later when they are considering what to study in college (ESRI, 2019).

Among the actuarial undergraduate students in Ireland surveyed by the Working Group, 88% of male respondents who provided Leaving Certificate results had achieved a H1 grade in Higher Level Mathematics. This contrasted with 67% of female respondents who achieved the same result. Males who studied one, two or three additional mathematical subjects[29] for Leaving Cert. were more likely to achieve a H1 compared with those who studied Mathematics only. Females who studied one additional mathematical subject were less likely to achieve a H1 than those who studied Mathematics only. However, females who studied two additional mathematical subjects were more likely to achieve a H1 than those who studied Mathematics only. No female studied three additional mathematical subjects. Females who studied Applied Maths or DCG alongside Mathematics were more likely to achieve a H1 than those who studied Mathematics only, but females who studied Physics alongside Mathematics were less likely to achieve a H1 than those who studied Mathematics only. The results of this survey support the argument that studying additional mathematical subjects which help hone spatial reasoning skills such as Applied Mathematics and DCG increase the likelihood of achieving a H1 grade in Higher Level Mathematics.

[27] Programme for International Student Assessment

[28] Annual Exam Statistics - State Examination Commission (examinations.ie)

[29] Physics, Applied Mathematics & Design and Communication Graphics (DCG)

Single-sex v mixed-sex schooling

Ireland has the second highest proportion of single-sex schools in Europe, second only to Malta, and among the highest proportion of single-sex schools globally, outside of the Arab world. An analysis of data from 5,000 15-year-olds in Ireland, published in 2023, found "no academic advantage" for teenagers attending single-sexed or mixed-sex schools. The research examined the association between attending a single-sex school and performance in maths, reading and science[30].

The impact of single-sex education on the gender difference in mathematical achievement at the top of the distribution for primary school children in Ireland was examined in 2013. It was found that while there was a significant gender gap favouring boys, there was no evidence that single-sex schooling reduces the gap. In fact, the researchers concluded that the gender differential in mathematical achievement at the top of the distribution was larger for children educated in single-sex schools than in coeducational schools (Doris, et al., 2013). The Working Group survey of undergraduate actuarial students in Ireland found no material difference in the proportion of males or females who attended single-sex or mixed secondary schools but must be noted that the sample size was small. Leaving Certificate results have been reported at a composite level by gender and by school type (single-sex v mixed) for the years 2016 to 2021 (State Examinations Commission, 2021). A further breakdown of Leaving Certificate Mathematics results by gender for both single-sex and mixed schools would be very insightful.

Teaching Methods

A more student-centred teaching approach was advocated with the introduction of Project Maths, placing greater emphasis on investigative learning in realistic or applied contexts (Department of Education and Skills, 2015). With the phased introduction of the new mathematics curriculum, teachers across the country engaged in substantial professional development focused on methodologies, use of dynamic software, and teaching through problem solving. In parallel, hundreds of out-of-field teachers were upskilled through universities. However, in TIMSS 2015, it was found that one fifth of students were still taught by teachers whose main area of study was something other than mathematics. This proportion was considerably larger than that of the highest achieving countries (Roche, et al., 2019).

Research published in 2022 suggests that teachers have struggled to adopt the recommended changes in teaching practices during the ten years since Project Maths was launched and that there is a need for more professional development to increase teachers' level of comfort with the student-led pedagogies promoted by the reformed curriculum (Berry, et al., 2022). The results showed that among teachers surveyed, "direct instruction (chalk and talk)" – a method that was intended to be de-emphasised for Project Maths – was still the most frequently used teaching method. Respondents were less comfortable in using the more "reform-type" methods promoted for Project Maths. The factor most influencing the teachers' choice of approach was 'time.' Student-centred teaching methods were seen as more time-consuming, and teachers felt pressure to use direct instructional methods to ensure content coverage. 65% of respondents did not believe that they have adequate time to complete the course, and only 19% considered their pace as one that "suits" the students. Teachers' comfort and experience, and the profile of the group being taught, were other factors receiving considerable endorsement. Specifically, there was a sense that the cohorts of students attempting Leaving Cert. Higher Level Maths are less academically strong than for previous Higher-Level curricula, given the allure of extra points.

[30] Single-sex schools provide 'no academic advantage', study finds – The Irish Times

Bonus Points

The introduction of the flat bonus points system for Leaving Cert. Higher Level Maths in 2012 has led to a significant increase in the proportion of students sitting Higher Level Maths. The overall proportion of Leaving Certificate students sitting Higher Level Maths increased from 14.5% in 2011 to 36% in 2023. As illustrated by Figure 8 below, there was a marked improvement in participation rates for both males and females, with male and female participation rates converging by 2022. There was a slight divergence in 2023 with the female participation rate falling slightly below the male participation rate.

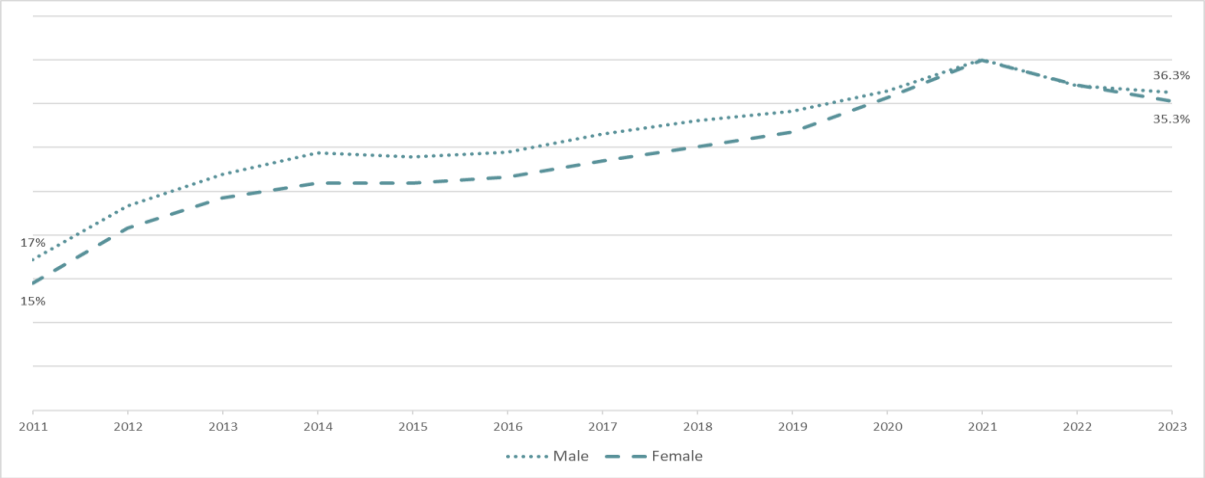

Figure 8: Leaving Certificate Higher Level Mathematics - Male and Female Participation Rate as percentage of the overall population of Leaving Cert. students (2011-2023)

One teacher surveyed expressed the view that "Bonus 25 points encourages students who are not able for Higher Level to hang on… ultimately increasing time constraints on teacher" (Berry, et al., 2022). It is possible that the time constraints referred to may be impacting the amount of time devoted to practicing problem-solving exam questions which may in turn be impacting the performance of female students at the highest attainment level, thus contributing to the widening gender gap.

No formal or publicly available evaluation of the current bonus points scheme has taken place to date, even though the scheme was introduced on a four-year pilot basis in 2012 (McCoy, et al., 2018). However, a national study was undertaken by Dr. Niamh O'Meara (UL), Dr. Mark Prendergast (UCC) and Dr. Páraic Treacy (University of Brighton) in 2020 to investigate teachers' perspectives on the current Bonus Points system. This study found that although the overall participation rate in Higher Level Maths has increased significantly since 2012, overall mathematical proficiency has not necessarily improved. Teachers surveyed as part of this study observed that many students who teachers would not consider suitable for Higher Level are now opting for this course of study. As a result, there is a much greater range of abilities in Higher Level Mathematics classes than was the case prior to 2012. This study observes that the current Bonus Points system was introduced without any apparent consideration for the impact it may have on class profiles and as such, teachers received no training in dealing with the knock-on effects of a radical change in the typical ability profile of a class, including guidance on how to develop teaching strategies to cater for more mixed ability classes.

Researchers have found that mathematics is one of the more difficult subjects for working with mixed ability groupings and that mixed ability grouping is inappropriate for mathematics. The study concluded that without some additional changes and revisions, the current Bonus Points system will simply serve to attract students, in an exam driven system, to study a subject that they do not value and force teachers to engage in teaching styles that they may not be familiar with or have any training in (O'Meara, et al., 2020).

Examination Content

One of the key changes introduced as part of Project Maths was the introduction of "Context and Application" questions. Prior to 2012, the questions in the Leaving Cert. Mathematics papers were familiar, albeit difficult and challenging book type questions e.g. Question 1 from 2009 would be very typical of such a question, as follows:

Find the value of x/y when

$$(2x+3y)/(x+6y) = 4/5$$

Question 2 from the same paper starts with:

Solve the simultaneous equations

$$X-Y+8 = 0$$
$$X^2 + XY + 8 = 0$$

Simply put, the nature of the questions is that the candidate is presented with a mathematical problem / equation etc. and asked to solve.

In 2012 however, as part of the introduction of Project Maths, new "Context and Application" questions were introduced which account for 50% of marks on both paper 1 and paper 2. There are several features about these questions which are very different to what went before:

First, they present the student with an "unseen" scenario, i.e., unfamiliar topic. These topics have included for example:

- A cylindrical tank of water with a hole towards the bottom
- A company manufacturing conical drinking cups
- The atmospheric pressure of the earth
- The shape of the arch of the foot bridge at Mizen Head
- Cooling boiling water for baby food preparation

To illustrate further, the above cooling boiling water example question 9 from 2014 Paper 1 starts as follows:

"Ciarán is preparing food for his baby and must use cooled boiled water. The equation $y = Ae^{kt}$ describes how the boiled water cools. In this equation:

- *t is the time, in minutes, from when the water boiled,*
- *y is the difference between the water temperature and room temperature at time t, measured in degrees Celsius,*
- *A and k are constants.*

The temperature of the water when it boils is 100°C and the room temperature is a constant 23°C.

(a) Write down the value of the temperature difference, y, when the water boils, and find the value of A."

Then the student must translate the scenario presented into a mathematical problem. In addition, each problem is very long and consists of several (typically four to sometimes eight) parts in sequence. These subsequent parts of the questions often depend on answering the previous parts correctly.

We believe that these questions can be very daunting for students, given the unfamiliar scenario presented, the requirement to translate the scenario to maths, the length of the questions and the need to get previous parts correct to attempt the subsequent parts.

Finally, it is worth noting that question choice in the Leaving Cert. exam papers was removed with the introduction of Project Maths. All questions must be answered by students (some choice was introduced during Covid as a gesture to make the exam somewhat easier during that difficult period).

We examined all 76 questions between 2012 and 2023 on papers 1 and 2 (three per year per paper up until 2020, with 4 questions in the Covid years). There was one scenario repeated, that of the cooling boiling water referenced above (2014), which appeared in 2021 as a cooling cup of coffee, with a similar formula. Outside this one exception, not one other scenario was repeated in those 76 questions, that we noticed. There appears to be a very deliberate strategy to present the Leaving Cert. students with these unseen type questions as part of Project Maths.

We were very conscious that the introduction of Project Maths, and these new question types, coincided with a very material widening of the gender gap for the highest performers. We were also aware that such a widening did not occur in A-Levels. We therefore also examined the last 4 years of A-Level papers from Northern Ireland. It is very noticeable that the A-Level Pure Maths papers are similar to the Leaving Cert. papers prior to Project Maths. There are no questions that are comparable to Project Maths "Context and Application" questions. The only exception to this is in the Applied Maths papers; but in that case the questions are very similar to Leaving Cert. Applied Maths Leaving Cert. papers.

We then of course wondered if these "Context and Application" questions were the main driver of the widening gender gap for our highest performers. There has in fact been some interesting research carried out on this topic. Per (Roche, et al., 2019), "When dealing with novel tasks and problems set in unfamiliar contexts, such as the new HL LC examination, students are rewarded less by rote-learning and algorithmic practice and more by spatial ability and application of working memory". (Roche, et al., 2019) also cites research that stated, "Researchers have frequently found gender differences in spatial ability in favour of males (Reilly & Neumann, 2013)". They go on to say that "Early-stage research in Ireland suggests that this spatial ability gap widens as students move through post primary school (Harding, 2018). This is not unique to Ireland."

It appears, therefore, that there is Irish and international academic evidence that strongly points to a serious issue here. The "Context and Application" questions which were introduced as part of the Project Maths syllabus require spatial reasoning. There is a known gender gap in spatial reasoning which widens through secondary school. Therefore, we conclude that these questions materially discriminate against female students, and is highly likely to be the key driver to the widening gender gap for high performers in the Leaving Cert. This appears to be uniquely an Irish problem brought about by Project Maths question styles.

Junior Cycle

Project Maths was rolled out at Junior Certificate level between 2011 and 2015. 2022 was a significant year in that it marked the replacement of the Junior Certificate Maths examination with the new Junior Cycle examination. Although the mathematical content of Junior Cycle Maths was broadly unchanged, it did involve a different approach to teaching, learning and assessment, with greater emphasis on learning through problem solving (Berry, et al., 2022). 2022 also marked the introduction of a new grading system. Figure 9 overleaf describes the female participation rate in Junior Cert. Higher Level Mathematics and the proportion of the highest attainment grade awarded to females each year from 2001 to 2022.

No Junior Cert. examinations were held in 2020 or 2021 due to the Covid-19 outbreak. Figure 9 illustrates the difference between the female participation rate in Junior Cert. Higher Level Mathematics and the percentage of the highest attainment grade awarded to females each year from 2001 to 2022.

Figure 9: Junior Cert. Higher Level Maths - Female Participation Rate v Proportion of highest grade awarded to females (2001-2022)

Worryingly, there was a very sharp drop in female performance at the highest grade in 2022. This resulted in the gap between the female participation rate at Junior Cycle level and the proportion of the highest grade awarded to females at Junior Cycle level widening significantly. Although just over half of students who sat Junior Cycle Higher Level Maths in 2022 were female, only 34% of those achieving the highest grade of 'DN' (Distinction) were female. The significant widening of the gender gap at the highest Junior Cycle attainment grade is a very concerning development.

4. Factors Influencing Career Choice

Mathematics and Statistics at third level

Data published by the CAO[31] shows that the average female proportion of all new entrants to Mathematics and Statistics undergraduate courses in Ireland over the period 2016 to 2022 was 29%. This was consistent with the average female representation across the DCU, UCD and UCC Actuarial undergraduate programmes over the same period. It is also consistent with the current female proportion of SAI student members. Medicine, Law, Physiotherapy, Dentistry, Pharmacy and Veterinary undergraduate courses attracted more females than males during the same period. There was no material difference between the gender profile of CAO first preferences for Mathematics and Statistics courses and CAO offers. This suggests that the gender gap occurs at the CAO application stage rather than the CAO offer stage.

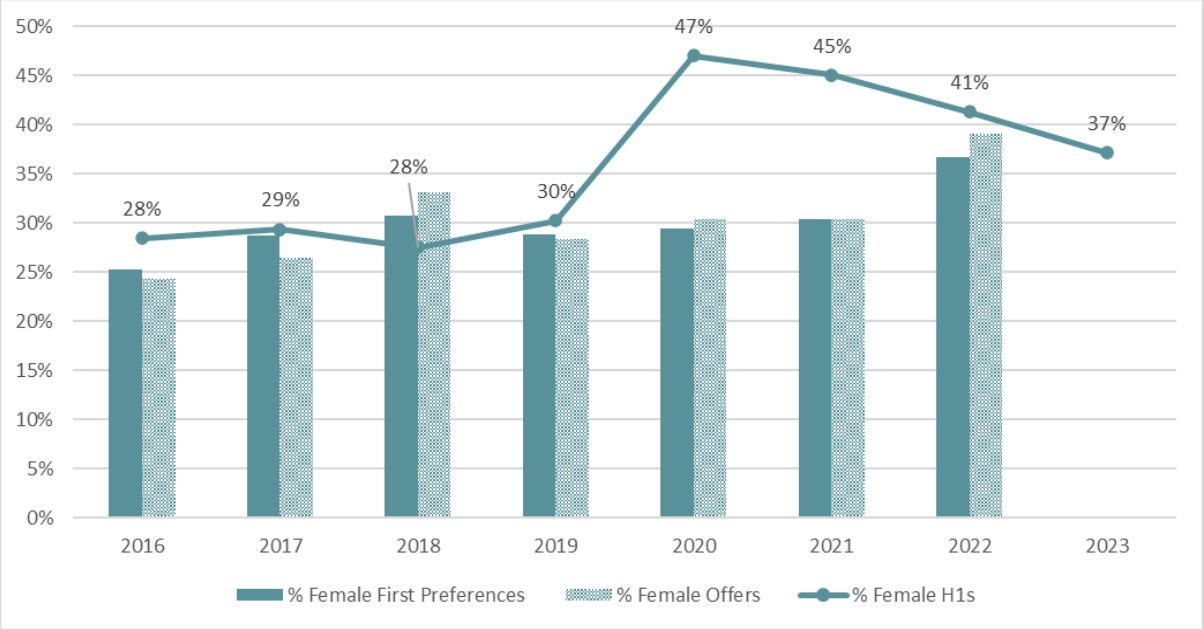

Figure 10: Percentage of H1s in Leaving Cert Higher Level Maths achieved by females v Female proportion of CAO first preferences and offers for Maths and Statistics courses from 2016 to 2022

Figure 10 shows that the proportion of female first preferences and offers to Mathematics and Statistics undergraduate courses via the CAO over the period 2016-2019 was strikingly similar to the proportion of females achieving a H1 in Leaving Certificate Higher Level Mathematics over the same period. The higher proportion of females achieving a H1 in both 2020 and 2021 under the predictive grading system was not mirrored by a jump in the proportion of female first preferences for Mathematics and Statistics courses that year. However, the proportion of female first preferences and offers for Mathematics and Statistics courses did increase in 2022 to almost 40%. This was very close to the proportion of H1s awarded to females in the 2022 Leaving Certificate Higher Level Mathematics examination. Data on 2023 CAO applications to Mathematics and Statistics courses was not publicly available at the time of writing. The widening of the gender gap in absolute terms in 2023 suggests that this trend may not be permanent.

The average female proportion of students entering the Queen's University Belfast (QUB) actuarial programme between 2016 and 2021 was 42%, notably higher than for actuarial programmes in the Republic of Ireland over the same period. Female representation on the Heriot-Watt University, York

[31] CAO Board of Directors Reports 2016 to 2022

University and Leicester University actuarial programmes in the UK over a similar period was also c.40%. This was very close to the overall female participation rate for A-Level Maths in England over the same period[32]. However, although almost half of students who sat Leaving Certificate Higher Level Maths between 2016 and 2021 were female, just under a third of new entrants to the DCU and UCD actuarial degree programmes were female.

An analysis of academic performance by gender on Mathematics and Statistics courses across five Irish universities was undertaken by the winners of the 2022 Society of Actuaries Student Competition[33]. The analysis covered the period from 2012 to 2017 and demonstrated that, although females were significantly underrepresented, they tended to achieve higher grades on average than males. In 2017, for example, although females accounted for 28.42% of the Mathematics & Statistics third-level students, 33.78% of first-class honours degrees were achieved by females.

Gendered approach to career choice

The results of an OECD study on the work hopes of 500,000 15-year-olds in 79 countries and economic areas were published in 2020. The study entitled 'Dream Jobs? Teenagers' Career Aspirations and the Future of Work,' featured analysis from PISA[34] on the kinds of careers boys and girls expect for themselves. Becoming a doctor was the most aspired-to career among girls who took part in the study. This was followed by teaching and business management. Training to be a lawyer, nurse or midwife, psychologist, designer, veterinarian, police officer and architect were also among the popular careers mentioned by girls. Among high performers in mathematics or science, for example, boys were much more likely than girls to express an interest in becoming a scientist or engineer. The reverse was true for health-related careers, which girls favoured[35]. A 2015 PISA report found that, in almost all countries, boys were more likely than girls to envisage themselves in a science or mathematics related career (OECD, 2018).

A survey of 2,583 teenage girls in Ireland undertaken by iWish in 2022 found that although teenage girls are increasingly interested in STEM careers, two-thirds said that persistent lack of gender equality in STEM was a barrier to a STEM career. Almost half of those surveyed said that stereotypes were a reason for the lower participation in STEM careers by women. Two-thirds of the teenage girls surveyed said there was insufficient information on such careers, while 61 per cent said they did not have access to work experience in the field. The survey found more than half of teenage girls lacked confidence in their ability to pursue a STEM career, and 52 per cent said a lack of female role models was a factor[36].

Research published in 2021 found that gender differences favouring males remain prevalent regarding attitudes to mathematics among Irish teenagers. These differences were particularly strong regarding interest, self-belief, and attitudes to problem-solving. Finally, while female students saw the value and importance of mathematics in their lives to some extent, many of these females did not value it enough to wish to pursue a career in the area. This finding is of particular interest in the Irish context, given the government's current policy on STEM education. With the objective of becoming European Leaders in STEM education by 2026, the government aims to increase uptake and to enhance positive attitudes towards STEM for all learners, with particular focus on female students (Department of Education and Skills, 2017).

[32] A level outcomes in England (ofqual.gov.uk)
[33] STEMinism: Kate Corcoran, Emily Walsh & Joseph Wetz (UCC, 2022)
[34] Programme for International Student Assessment
[35] Which jobs do teenage girls and boys aspire to have by age 30? – The Irish Times
[36] Teenage girls increasingly interested in STEM careers, new survey shows – The Irish Times

At Junior Cycle, it was found that girls' confidence in mathematics remains significantly lower than that of boys. Student self-belief has been found to be a key factor in making mathematics related career choices. It has also been found that the lack of women in STEM careers negatively impacts the self-belief of female post-primary mathematics students. This creates a vicious circle whereby females are choosing not to enter STEM fields due to low self-belief, which then further impacts the self-belief of future female mathematics students. Gender discrepancy in STEM careers has also been attributed to men having a lower desire to work with people in altruistic professions as well as having a higher mathematical self-concept than women (O'Rourke & Prendergast, 2021).

An ESRI report published in 2019 established that boys and girls in Ireland use different decision-making strategies when deciding whether to choose STEM third level courses. This research was based on CAO data from 2015 to 2017. Girls performed better, on average, in the Leaving Certificate examinations with boys doing better in Mathematics and girls doing better in English and in most other subjects. It was found that 57% of boys do better in Mathematics than English compared to 37% of girls. While English and Mathematics grades will not capture all aspects of comparative advantage, they have been found to be strong predictors of STEM career choices. The probability of choosing a STEM career increased with Mathematics grades and decreased with English grades. It was found that boys were more likely to choose a STEM career based on their individual comparative advantage in Mathematics relative to English, while girls were more likely to decide based solely on their absolute advantage in Mathematics (ESRI, 2019). This research also established that comparative advantage played a larger role for higher achieving students. The differing approach to career choice is particularly relevant in an Irish context where boys consistently outperform girls at Leaving Certificate Higher Level Mathematics and girls consistently outperform boys at Leaving Certificate Higher Level English (ESRI, 2019).

One theory put forward by a Norwegian researcher as to why so few girls enter male-dominated occupations is that they have a larger range of alternatives that they find acceptable compared to boys. In combination with expectations of discrimination in male-dominated occupations, or social costs associated with gender-atypical choices, this might lead to many girls opting for 'safer,' female-dominated alternatives (Seehuus, 2021).

A 2019 YouGov survey undertaken in the UK found that females were more likely than males to seek out a career which they perceive as being meaningful[37]. A 2019 PwC report found that females were much more committed than males to choosing a career that enables them to make a positive difference to the world around them[38]. 50% of the females interviewed for the PwC study said the most important factor when choosing their future career was "feeling like the work I do makes the world a better place/has a wider impact". The corresponding figure for men was only 31%. In fact, females rated the opportunity to make the world a better place as the second most attractive attribute of a career, with only "having interesting work" ranking higher for them. In contrast, males were more likely to cite salary as an important factor – with 44% of males saying this, versus 32% of females.

Research has also established that female students are more likely to choose people-oriented careers, while male students are generally more interested in wealth and competitive position (Sallop & Kirby, 2007). The survey of third-level actuarial undergraduate students in Ireland undertaken by our Working Group also found that male students were more likely than females to cite earnings potential as a factor which influenced their degree choice. However, these results should be interpreted with caution given the relatively low number of students citing this factor (17% of males cited earnings potential as a motivating factor compared with 13% of female students).

[37] Tiger Recruitment research: Meaningful work more important to women (tiger-recruitment.com)
[38] women-in-tech-report.pdf (pwc.co.uk)

Females have also been found to place more emphasis on work-life balance than males (Sallop & Kirby, 2007). It would be very interesting to establish if young Irish females perceive work-life balance within the actuarial profession to be materially different from that of the legal and accounting professions, both of which now attract more female new entrants than males in Ireland.

Gender stereotypes

In 2017, Dr Brian McCraith, President of Dublin City University, cited 'multiple reasons for the gender imbalance in STEM careers in Ireland: a lack of female role models in STEM, the views of parents, the language used in promoting STEM and unconscious bias'[39].

A 'Growing Up in Ireland' study[40] undertaken in 2021 found strong evidence of unconscious gender bias in favour of boys at mid-primary level, with both mothers and teachers overestimating boys' mathematical ability and underestimating girls' mathematical ability. Based on a study of 8,500 eight-to nine-year-olds, teachers and mothers were found to have lower assessments of girls' performance, taking account of their mathematics achievement, school engagement, liking for mathematics, their self-concept, and their economic, educational, and cultural background (McCoy, et al., 2022). It was suggested that female teachers were less likely to rate girls highly in mathematics, taking account of performance, due to their own lack of confidence in mathematics assessment. Mothers' gender bias was evident among high performing children and at all levels of children's academic self-concept. Surprisingly, the gender bias towards males was also most evident among college-educated mothers. This unconscious gender bias is likely to be adversely impacting females' mathematical confidence right up to Leaving Cert level as well as their career choices. Based on their findings, the researchers expressed concern that policy goals to increase the numbers of girls in STEM fields are likely to be ineffective, since girls will have learned that even if they excel in this area, their teachers and mothers will not necessarily see them as excelling.

[39] Placing gender equity in Stem on the radar – The Irish Times

[40] Do teachers and mothers overestimate boys' and underestimate girls' mathematics performance? – Public Policy

5. Recommendations

Recommendations for the Department of Education

We have divided our recommendations into two parts - primary and secondary recommendations. The primary recommendations directly address the changes that occurred as a result of the introduction of Project Maths, the timing of which was strongly correlated with the widening of the gender gap. But critically we also believe that some of these changes, at least, are a key driver of the widening of the gender gap.

a) Primary Recommendations

The gender gap at the highest attainment level for Higher Level Mathematics in Ireland, at Leaving Certificate level and more recently at Junior Cycle level, is extremely concerning.

i. ***We strongly recommend that an academic review of the approach to examining the Project Maths syllabus is undertaken with respect to the introduction of unseen "context and application" style questions where spatial reasoning confers an advantage, to assess their impact on the widening gender gap.***

ii. *As part of this review,* ***we recommend the investigation of Leaving Certificate Higher Level Mathematics performance by gender by question, to see if the widening gender gap has been driven by specific question styles introduced as part of the Project Maths syllabus.***

iii. ***We recommend that females must be given equal opportunity to access subjects such as Applied Maths and Physics in schools that do not currently offer these subjects, because of their direct impact on improving performance in the Leaving Cert Maths applied questions****. Additionally, greater efforts need to be made to encourage females to consider choosing these subjects where they are currently available. If this is not possible, the inclusion of questions of this style on the Leaving Cert Maths exam must be seriously reconsidered on the grounds of fairness and gender discrimination.*

iv. *We strongly recommend that a review of the approach to preparing female students for the Project Maths exam is undertaken. The gender gap for Leaving Certificate Higher Level Mathematics at the highest attainment level since 2012 has been much wider than the corresponding gender gap for A-Level Mathematics in England.* ***We believe that a comparison of the teaching and examination approaches in both jurisdictions would be helpful in terms of understanding the drivers behind the wider gender gap observed in Ireland.***

We are also conscious that the introduction of 25 bonus points for all those achieving a mark of 40% or more in Higher Level Maths coincided with a significant increase with the numbers sitting Higher Level Maths, and the widening of the gender gap (though we are not suggesting this is a cause). This in turn, we have been told, has led to teachers spending much more of their time with the weaker students who were struggling to attain the 40% mark. Understandably, this has then resulted in less time being spent on the higher performing students.

v. ***We recommend that the current teaching resources allocated to Leaving Cert. Higher Level Mathematics be reviewed in light of the larger class sizes and wider range of abilities present since the introduction of the flat bonus points system.***

vi. *Finally,* ***we recommend that the results of all the above investigations (including this report) be presented to the Minister for Education and that on publication an information event be organised to discuss the findings with stakeholders.***

b) *Secondary Recommendations*

i. *The relatively low number of out-of-field mathematics teachers in Ireland relative to other jurisdictions should be addressed. This could be achieved by making it easier for other professionals with maths-related degrees to convert to teaching by for example:*

- *creating a one-year part time conversion course*
- *providing financial support to students*
- *recognising a wider range of degrees (such as engineering, financial mathematics, data science, actuarial science) as sufficient to teach maths up to Leaving Cert. level.*

ii. *We recommend that a separate analysis of performance by gender for single-sex and mixed schools is undertaken, which would be very helpful useful in terms of understanding whether the gender gap is influenced by the gender profile of learning environments.*

iii. *We recommend that a comparison of the gender gap for unadjusted grades and adjusted grades in recent years is undertaken, which we believe would also be very helpful in terms of understanding the impact of post-marking adjustments and the likely impact of the future cessation of this practice.*

Recommendations for the Society of Actuaries in Ireland

a) *Profile of the profession*

The Working Group recommends that the Society of Actuaries should consider the following actions to raise the profile of the profession with the specific objective of attracting more female new entrants:

i. *The Role Models in pSTEM video project*[41] *(initiated by the Department of Mathematical Sciences at UCD) now features two female members of the SAI. We believe it is very important that the SAI actively markets the actuarial profession to young females, as well as their parents and teachers, using female role models.*

ii. *As well as marketing the profession to second-level female students, the SAI should also actively market the profession to third-level female students who have high levels of mathematical ability but are not studying non-actuarial degrees. These would include Business, Economics and Science students as well as those studying Mathematics and Statistics.*

[41] Role Models in pSTEM - UCD School of Mathematics and Statistics

iii. *Showcase the many and varied ways in which actuaries have made positive contributions to society in the past and can help solve future societal challenges. An Ambassador Programme could be launched for example. The very successful TY Work Experience Initiative which was piloted by the SAI in 2022 and 2023 should be expanded to reach more students in general, but with a continued emphasis on reaching female students.*

iv. *Highlight that flexible working environments which give rise to a more positive work-life balance are now commonplace within the actuarial profession and it is very important that young females are aware of this.*

v. *Investigate whether young Irish females perceive work-life balance within the actuarial profession to be materially different from that of the legal and accounting professions, both of which now attract more female new entrants than males in Ireland.*

vi. *Obtain and monitor the gender split of new entrants from employers on an annual basis as many actuarial students in Ireland do not join the SAI until they qualify.*

In order to achieve the above recommendations funding will be required. We recommend the following:

vii. *SAI work with Corporates to introduce scholarships for females interested in studying Actuarial Science*

viii. *SAI introduce a DEAI fund in order to continue to support initiatives such as the pSTEM videos and 'iWish' conference. iWish is a community committed to showcasing the power of Science, Technology, Engineering, and Maths to teenage girls[42]. The SAI exhibited at the i Wish conference in February 2023. This conference took place in the RDS and was attended by 3,000 Transition Year girls.*

b) Supporting second-level students

The Working Group recommends that the Society of Actuaries consider the following actions to support Leaving Certificate students:

i. *Expand the existing SAI Maths Tutorials programme to reach more female students without access to additional support.*

ii. *Pre-recorded maths lessons be made freely available to all students to allow female students access to additional teaching or coaching they may need at their own pace.*

iii. *The SAI could host a free app with videos and practice questions for all students.*

[42] iWish

6. Conclusions

The Working Group has identified a correlation between the decline in female proportion of new entrants to the actuarial profession in Ireland and the decline in female performance at the highest attainment grade in Leaving Cert. Higher Level Maths. The gap has been particularly pronounced since 2012, the year Project Maths was introduced. A significant performance gap at the highest attainment grade for Junior Cert. Higher Level Maths has also recently emerged. We believe the gender performance gap requires urgent attention. While it is clearly an issue for the actuarial profession, we believe it is also likely to be an issue for STEM careers more widely, both within financial services and beyond. In 2017, just 25% of STEM jobs in Ireland were held by females.[43] The gender performance gap is particularly relevant in the context of the Irish Government's current objective to become a European Leader in STEM education by 2026, through increasing uptake and enhancing positive attitudes towards STEM, with a particular emphasis on female students (Department of Education and Skills, 2017).

Females in Ireland continue to be under-represented in more senior roles in financial services in Ireland. While female representation in the general population of financial services firms tends to be equally balanced, significant differences emerge in the progression to more senior levels.[44] According to the Central Bank, 84% of the most senior roles in the sector were held by men as of December 2021.[45] If the current gender gap at entry level to the actuarial profession prevails, the achievement of higher female representation at leadership level within the actuarial profession will prove even more challenging in the future, with implications for the overall financial services picture since that is where most actuaries work.

A lack of female role models has been cited as one factor contributing to the gender gap in mathematics-based careers. We recommend that the SAI begins to actively market the actuarial profession to young females, as well as their parents and teachers, using female role models.

We believe there is an opportunity for the Society to highlight the many and varied ways in which actuaries have made positive contributions to society in the past and can help solve future societal challenges. By marketing our profession more actively to young females, as well as their parents and teachers, the SAI can encourage more young females to choose an actuarial career and play an important role in helping to extinguish cultural gender stereotypes associated with mathematics-based careers.

[43] Placing gender equity in Stem on the radar – The Irish Times
[44] Partners – Balance for Better Business (betterbalance.ie)
[45] Why do so few women reach the top ranks of financial services? – The Irish Times

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The Institute and Faculty of Actuaries

About the Working Group

This Working Group was established by the Diversity, Equity, Accessibility, and Inclusion (DEAI) Committee of the SAI. Members were recruited through an open call to all members of the SAI. The members of the Working Group were:

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About the Society of Actuaries in Ireland

The Society of Actuaries in Ireland is the professional body representing the actuarial profession in Ireland. The Society is dedicated to serving the public by fostering the highest standards of professionalism and competence in actuarial practice.

Our ***Vision*** is that *Actuaries are trusted as experts in evaluating risk and financial uncertainty.*

*Our **Mission** is to:*

1. ***Support actuaries throughout their career*** *so that they have the skills, attributes, and knowledge appropriate to their roles and the current and future needs of actuarial practice;*

2. ***Develop, maintain, and enforce actuarial standards*** *that require actuaries to advise their clients with integrity, professionalism, and objectivity;*

3. ***Serve the public interest*** *by promoting thought leadership and contributing as an independent voice on matters where an actuarial perspective can add value.*

Disclaimer

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