Mathematics in Ireland's upper secondary schools: Why do students choose higher-level maths?

Niamh O'Meara
University of Limerick, Ireland
Mark Prendergast
University College Cork, Ireland
Páraic Treacy
Mary Immaculate College, Ireland

There is a body of research which highlights the importance of students studying mathematics at an advanced level, hence policy-makers worldwide look for ways to increase the uptake of advanced mathematics. In Ireland, the Government announced the introduction of a Bonus Points Initiative which came into effect in 2012, in an attempt to increase the number of Senior Cycle students opting to study higher-level mathematics and to improve Irish students' mathematical capabilities. Despite a rise in the number of students studying higher-level mathematics, very little research has been conducted to determine if it was the Bonus Points initiative, a reformed mathematics curriculum, or other factors that led to the surge in uptake. To address this gap in the research, this study investigates Irish students' reasons for participating in higher-level mathematics and seeks to determine if such reasons differ across gender, school type, or prior attainment levels. The findings suggest that the points system used by Ireland's Central Applications Office for entry to post-secondary education (CAO, n.d.), in particular the provision of Bonus Points for higher-level mathematics in Ireland, is the main driving factor behind students' participation in higher-level mathematics, with parents also being influential in decision-making. Significant differences in the reasons offered by males and females were found, while prior attainment seemed to have the biggest influence on students' reasoning regardless of gender.

Introduction

There is a large body of growing research which highlights the importance of students studying mathematics at an advanced level (Attridge & Inglis, 2013). Mujtaba, Reiss and Hodgson (2014) found that students who studied advanced mathematics, henceforth referred to as higher-level mathematics[1], had a greater probability of securing a place at third level; had improved job prospects and in turn were more likely to have increased earnings compared to students who dropped mathematics at the end of lower secondary school. This point was further emphasised by Mathieson et al. (2020: 707). When comparing the benefits associated with a range of A-level subjects in the UK they found

[1] In many countries, such as the UK, students make a decision on completion of lower secondary education whether they wish to pursue mathematics at upper secondary school. In this paper this is what we consider higher level mathematics in such countries. In other countries, such as Ireland, where this study is situated, students are not given a choice about whether or not they will continue to study mathematics but only have a choice about the standard they wish to study it at. In Ireland the highest standard that students can study mathematics at in upper secondary school is known locally as higher-level mathematics also.

that "the advantage of having A-level Mathematics outstrips the advantages of having A-levels at all: of all post-16 qualifications, A-level Mathematics has the greatest exchange value…". In addition to this, the literature also highlights the importance of higher-level mathematics for developing students' logical thinking and reasoning skills – skills that will serve students well in all walks of life. In a year-long study of 124 students conducted by Attridge and Inglis (2013) in the United Kingdom, all students were required to complete an assessment at the beginning and end of upper post-primary education. Attridge and Inglis (2013) recorded differences in the conditional reasoning abilities of higher-level mathematics students compared with those who did not opt to study mathematics once it was no longer compulsory. The results from this study showed that those students studying higher-level mathematics developed their conditional reasoning to a much greater extent than those students studying other subjects at an advanced level, despite the mathematics curriculum placing no specific emphasis on conditional logic.

Furthermore, Chinnappan et al. (2007) stated that higher-level mathematics facilitates the development of a variety of skills that underpin a scientifically literate workforce. Sheldrake, Mujtaba and Reiss (2015) elaborated on this when they conducted another longitudinal study amongst 1,085 Year 10 and 12 students, finding that studying higher-level mathematics in upper secondary school equipped students with the skills necessary to solve problems in the areas of physical sciences; computer sciences; engineering and medicine. Kennedy, Lyons and Quinn (2014) added that higher-level mathematics courses in high school are critical if we are to produce graduates who are capable and confident in making informed decisions about various real-life issues. In the UK, Sheldrake, Mujtaba and Reiss (2015) recognised that the skills acquired when studying mathematics in its most advanced form can help improve students' knowledge and skills in other STEM disciplines. This finding was also supported by Lyakhova and Neate (2021) who recognised that the study of advanced mathematics at second-level equips students with the skills necessary for an array of scientific disciplines. As a result of this, increasing the number of students studying higher-level mathematics will benefit the wider economy.

Similar claims have been made by researchers such as Chinnappan et al. (2007) and Kennedy Lyons and Quinn (2014) as they hypothesised that there was a correlation between participation rates in higher-level mathematics and participation in other science subjects. Furthermore, in Ireland, where this study is situated, many science, engineering, and technology Level 8 degree programs have minimum requirements for attainment in higher-level mathematics, known locally as the Leaving Certificate higher-level mathematics curriculum. As a result, students who do not opt to study mathematics in its most advanced form at upper secondary school level in Ireland will limit the options available to them at third level. This can have a detrimental effect on the potential supply of graduate recruits for third-level science, technology, engineering, and mathematics (STEM) courses (EGFSN, 2008). Hence, ensuring a good supply of second level graduates who have studied higher-level mathematics at upper secondary level is particularly important in Ireland where the Government have set a goal that the country will become a leader in Europe with regards to developing and deploying STEM talent by 2026 (DES, 2017).

Despite the importance of higher-level mathematics, many countries worldwide have reported low numbers of students opting to study mathematics in its most advanced form in upper secondary school. For example, in Australia, Goodrum, Druhan and Abbs (2012) found that all high school science subjects, mathematics included, were experiencing dramatic declines. Wilson and Mack (2014) tried to quantify this problem in New South Wales, finding that the number of students not studying any form of mathematics at upper secondary level had trebled between 2001 and 2013. Furthermore, the Mathematical Association of New South Wales found that 51% of teachers believed that students who were capable of studying mathematics at higher-level in upper post-primary school were opting not to, and rather were electing to study mathematics in a more diluted form. Similar findings were also reported in the work of Kirkham, Chapman and Wildy (2020). In addition to this, in the UK participation in higher-level mathematics, that is mathematics post-GCSE level (age 16), has been a cause of concern for many years. Hodgen et al. (2010) stated that England had one of the lowest rates of uptake of higher-level mathematics worldwide, with fewer than one in five students opting to continue their study of mathematics at upper secondary level. Similar findings were more recently echoed in the work of Noyes (2013) who found that only 10-15% of 16-year-old students choose to continue their study of mathematics and he reported that this figure is low when compared with other developed countries.

Similar problems have been reported internationally. For example, in Estonia, high school students must pass a minimum of five examinations (three externally set and graded and a minimum of two internally set and graded) in order to graduate from high school. For the externally set examinations, one must be in the subject area of Estonian or Russian while the remaining two can be selected from a list of eight other subjects. In 2010, 9.4% of students in their final year of high school chose to study mathematics for these external examinations compared with 16.8% who chose to study English and 13.6% who opted to study geography for these exams (Hodgen et al., 2010). Another example of this poor uptake of advanced mathematics among upper secondary school students was reported in the USA by Snyder (2011). He found that the mean number of Carnegie credits (a standard of measurement that represents one credit for the completion of a 1-year course) earned in high school for mathematics in 2005 was 3.7 while the average number of English and social sciences credits students earned stood at 4.4 and 4.0, respectively. Similar findings in relation to the poor uptake of advanced mathematics have also been reported in India (Garg & Gupta, 2003) and France (Charbonnier & Vayssettes, 2009).

Due to the economic and personal benefits associated with studying higher-level mathematics and the issues just discussed in relation to low uptake of the subject in its most advanced form internationally, it is important to understand the reasons why students opt to study or not study higher-level mathematics. However, Reiss et al. (2010: 273) stated that there is a dearth of studies into the "…reasons for the take-up or non take-up of mathematics and science at the point at which these studies become optional". In the intervening years many researchers (e.g. Reiss et al. 2011; Nagy et al., 2010; Hine, 2019) have invested a lot of time and effort into identifying possible reasons why students *do not* continue to study mathematics in upper secondary school. A range of different reasons have been identified including low levels of perceived competence in mathematics among students (Nagy et al., 2010); students' dissatisfaction with mathematics (Hine, 2019); prior experiences of mathematics (Ng, 2021) perceived level of difficulty of the subject (Hine, 2019) and the excessive amount of time that the subject requires in order to succeed (Chen & Liu, 2009).

However, very little research has been conducted internationally, or in Ireland, to determine the reasons behind students' decision to pursue higher-level mathematics, despite calls from the Royal Society in 2011 for further research into the motivations behind students' subject choice in upper secondary school. They believe that uncovering these motivations may help policy makers and educators to develop more strategies that will help to improve uptake of certain subjects at post-primary level. Similarly, the authors of this paper believe that when students are required to study mathematics at upper post-primary level, as is the case in Ireland, an investigation into the motivations behind students' decision to pursue higher-level mathematics will yield the same benefits. It is envisaged that such a study will assist policy makers and educators in developing ways to increase the number of students opting for higher-level mathematics, to improve retention in higher-level mathematics, and to enhance performance in the subject, thus helping to ensure the supply of graduates needed for a scientifically literate workforce.

The Irish context

In Ireland, secondary education is divided into two cycles. The *Junior Cycle* constitutes the first three years of secondary education when students are aged between 12-13 and 15-16. In 2014 a reformed Junior Cycle was rolled out in Ireland on a phased basis and this reform involved significant changes to how students were assessed in lower secondary school. In mathematics, Junior Cycle students are now assessed using a mix of continuous and summative assessment with the summative assessment taking the form of an externally set mathematics exam at the end of the three-year cycle. This final examination is much more heavily weighted than the continuous assessment component of the new assessment mechanism, with the latter contributing only 10% to a student's final score for Junior Cycle mathematics (NCCA, 2020).

Senior Cycle is a two-year cycle that follows the Junior Cycle, with an optional "gap year", known locally as Transition Year, offered to students between Junior and Senior Cycle. While the mathematics curriculum at Senior Cycle was reformed in 2010, with the introduction of *Project Maths*, which placed a much stronger emphasis on conceptual understanding and problem solving, there were no changes to assessment nor has there been any changes in the intervening years. Mathematics continues to be assessed at Senior Cycle solely through a summative examination known locally as the Leaving Certificate. For this examination, students can study three different mathematics curricula, each with a varying level of difficulty. Higher-level is the most advanced form of mathematics that students can study at Senior Cycle. Students must study mathematics at this level to secure a place on many third level courses in the fields of engineering, medicine, science and mathematics. Ordinary level is the next level down. Ordinary level covers many of the same concepts addressed at higher-level but not to the same level of detail or difficulty.

Furthermore, some topics such as integral calculus and hypothesis testing appear on the higher-level course but not the ordinary level course. Foundation level is designed for people who struggle with ordinary level, and it covers basic mathematical skills.

In Ireland, the uptake of mathematics at upper secondary level is not a cause for concern. For example, in 2019, 98.3% of students sitting the Leaving Certificate studied mathematics at one of the three levels discussed previously. The reason for this is that while mathematics is not a strictly compulsory subject at upper secondary level, it is treated as such by schools since higher and ordinary level mathematics act as gatekeepers for the vast majority of third-level courses. Thus, studying mathematics for Senior Cycle is typically expected of all students and this is reflected in the numbers studying mathematics each year. However, for many years there has been concern around the low numbers of students opting to study higher-level mathematics. For example, in 2011 15.8% of Irish students opted to study higher-level mathematics for their Leaving Certificate compared with 63.7% for English, 73.4% for physics, 81.7% for chemistry, 74.7% for biology, and 32.2% for Irish. In order to address this problem, and to improve the standard of mathematics among second level graduates, the Irish government introduced the *Bonus Points Initiative* (BPI), thus assigning higher-level mathematics with a unique status in secondary schools.

In Ireland, the Leaving Certificate exam acts as a gatekeeper to tertiary education. Students are awarded CAO points (CAO, n.d.) based on their achievement in six of their subjects in the Leaving Certificate examinations. Prior to the introduction of the BPI, the maximum a student could achieve in any given subject was 100 points (Table 1), thus the maximum number of points they could achieve overall was 600. This changed in 2012 with the introduction of the BPI which awarded students an extra 25 points for achieving a passing grade (>40%, labelled a H6 in the current grading system) in the higher-level Leaving Certificate mathematics examination. For example, a student awarded a H5 grade (50%-59%) would achieve 56 points and the additional 25 bonus points, resulting in a total of 81 points (Table 1).

Table 1: CAO points (CAO, n.d.) awarded for grades achieved in Leaving Certificate examinations

Examination score	Higher level grade	Points awarded	Ordinary level grade	Points awarded
100% - 90%	H1	100	O1	56
89% - 80%	H2	88	O2	46
79% - 70%	H3	77	O3	37
69% - 60%	H4	66	O4	28
59% - 50%	H5	56	O5	20
49% - 40%	H6	46	O6	12
39% - 30%	H7	37	O7	0
29% - 0%	H8	0	O8	0

After the introduction of the BPI, the proportion of students studying higher-level mathematics jumped from 15.8% in 2011 to 22.8% in 2012 and there has been a steady increase year on year ever since, with 32.9% of students sitting the higher-level mathematics exam in 2019[2]. The BPI appears to be the main reason for the surge in uptake of higher-level mathematics since 2012 but there is no evidence to confirm this is the case. Such evidence is necessary as in the same year that the BPI was introduced the reformed mathematics curriculum, *Project Maths*, was also introduced. This curriculum placed a much stronger emphasis on teaching mathematics for understanding and real-life applications so it is plausible that this too may have contributed to the surge in the uptake of higher-level mathematics, or it could be the case that other factors were also at play. This study seeks to determine which factors play a role in students' decision to pursue higher-level mathematics in a bid to determine if the BPI can be deemed as the driving factor in this recent surge in the proportion of students opting for higher-level mathematics in Ireland.

In order to address the aforementioned gaps in the literature, this study sought to determine Irish students' reasons for opting to study higher-level mathematics. As a result, the research questions underpinning this study are:

1. What are the most influential reasons behind students' decision to pursue higher-level mathematics in Ireland?
2. Do the reasons for studying higher-level mathematics differ across gender, school type, and/or prior attainment and if so, in what way?

Method

Research design

To address the research questions the authors chose a survey research design. They utilised a modified version of a survey which had been designed and validated for use in Queensland, Australia, another jurisdiction where incentives are in place for the uptake of higher-level mathematics (Jennings, 2014). Modifications were made to two items to reflect the Irish context of bonus points and CAO points. The study reported here was part of a wider study to investigate both higher and ordinary level students' motivations for choosing either higher or ordinary level mathematics. As such, for the broader study there were two versions of the survey developed: one for those who chose to study mathematics at higher-level and one for those who chose to study mathematics at

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[2] The proportion in 2020 (54.2%) was not relevant as only a small number of students completed the actual examinations in 2020, given that predicted grades were widely used due to implementation of measures related to the Covid-19 pandemic. In 2021, the vast majority of students took the option to be awarded either a predicted grade or their actual examination grade (whichever turned out to be better). As such, this cohort is difficult to compare to previous cohorts in their decision whether or not to opt for studying mathematics at higher level. In any case, the proportion was 40% in 2021.

ordinary level. For this paper, the authors will focus solely on the survey designed for students studying higher-level.

A survey was deemed to be the most effective tool to gather in-depth responses from a large number of participants, thus providing a diverse range of responses. It also ensures anonymity and hence encourages greater levels of honesty leading to more reliable data (Cohen, Manion, & Morrison, 2017). In total, there were 27 items included on the survey for higher-level students. *Section A* contained 4 items requesting basic information about the student (gender, current year of study, Junior Certificate level and grade). The opening part of *Section B* yielded quantitative data. Participants were provided with nineteen potential reasons, identified in the literature, for opting to study higher-level mathematics and asked to state, on a five-point Likert scale (1 = Strongly agree; 2 = Agree; 3 = Neither agree nor disagree; 4 = Disagree; 5 = Strongly disagree) if they agreed or disagreed that each of the reasons played a significant role in their decision to study mathematics at this level. The latter part of *Section B* yielded qualitative data. Here participants were asked to outline any other reasons, not given in the list of nineteen, that influenced their decision and to identify the reason, from all those listed, that was most influential in their decision to undertake higher-level mathematics. They were also asked to outline at what stage in secondary school they made the decision to pursue higher-level mathematics and how they reached this decision.

Sample

Ethical approval was granted for this study by the Faculty of Education and Health Sciences Research Ethics Committee in the University of Limerick in September 2019. Following this, participants were recruited through convenience sampling as the researchers contacted school administrators with whom they had previously worked. Upon obtaining permission from the gatekeeper at each school, the researchers provided consent forms to students who met the criteria (Senior Cycle students studying mathematics at higher or ordinary level) and, between October and December 2019 questionnaires were distributed to all students who had given consent to participate.

In total the authors sought to survey 2000 second level students and in order to achieve this number 12 schools were selected. Five vocational schools and seven secondary schools were invited to participate, aligned with the national school type breakdown. In Ireland, secondary schools are privately owned and managed. They are under the trusteeship of religious communities, boards of governors, or individuals. Vocational schools are owned and run by local Education Training Boards.

However, two schools withdrew, and the final sample consisted of three vocational schools and seven secondary schools. In total 1706 senior cycle students responded to the survey and 53.4% (N = 911) of the sample were studying higher-level mathematics at the time the survey was conducted. It is the responses of these 911 students that will be analysed and discussed in this paper. Table 2 outlines the gender and year group of the sample. 48.3% of the sample were male and 50.7% were female. 54.3% of the sample were in 5th year (the first year of Senior Cycle) while the remaining 45.7% were in 6th year (the final year of Senior Cycle).

Table 2: Sample demographics

	5th Year	6th Year	Total
Male	236	204	440
Female	254	208	462
Other/Prefer not to say	5	4	9
Total	495	416	911

The quantitative data were recorded and transferred into an *SPSS* (version 25) file for analysis. In order to address the first research question, the authors calculated descriptive statistics and produced graphs and tables based on this. For the second research question, comparisons needed to be drawn between different, mutually exclusive groups and, due to the nature of the data, Mann Whitney U tests were deemed most appropriate for this purpose. In this study, qualitative data also needed to be analysed to determine the nature of the reasons for the uptake of higher-level mathematics, other than those listed, that were provided by participants. Responses to this open-ended question were transcribed into a Microsoft *Word* file and then transferred to *NVivo* (version 11) for thematic analysis. Thematic analysis involves identifying, analysing and reporting patterns/themes across the data set. It is used to examine the ways individuals make meaning of their experiences and thus was relevant to this study (Braun & Clarke, 2006). Hence, the research team followed Braun and Clarke's (2006) six step approach during this analysis. These six steps are:

1. Familiarising yourself with the data;
2. Generating initial codes;
3. Searching for themes;
4. Reviewing potential themes;
5. Defining and naming themes;
6. Producing the findings.

The application of thematic analysis ensured a systematic examination and interpretation of the other reasons for choosing higher-level mathematics offered by participants so as to derive patterns and themes which informed our overall findings.

Results

The first research question sought to determine the reasons behind students' decision to study higher-level mathematics and to determine what factors were behind the recent surge in the uptake of higher-level mathematics in Ireland. Figure 1 shows students' level of agreement with the 19 reasons for studying higher-level mathematics. It shows that the three reasons which had strongest levels of agreement were: (1) *I wanted to get bonus points* (91.2% agreed or strongly agreed); (2) *I will get good CAO points from it* (80.3% agreed or strongly agreed) and (3) *my parents suggested I do it* (73.4% agreed or strongly agreed). This shows that CAO points (CAO, n.d.), and in particular the provision of bonus points, is one of the real driving factors in the uptake of higher-level mathematics in Ireland, while parents are the most significant actors influencing a student's decision to study mathematics at this level.

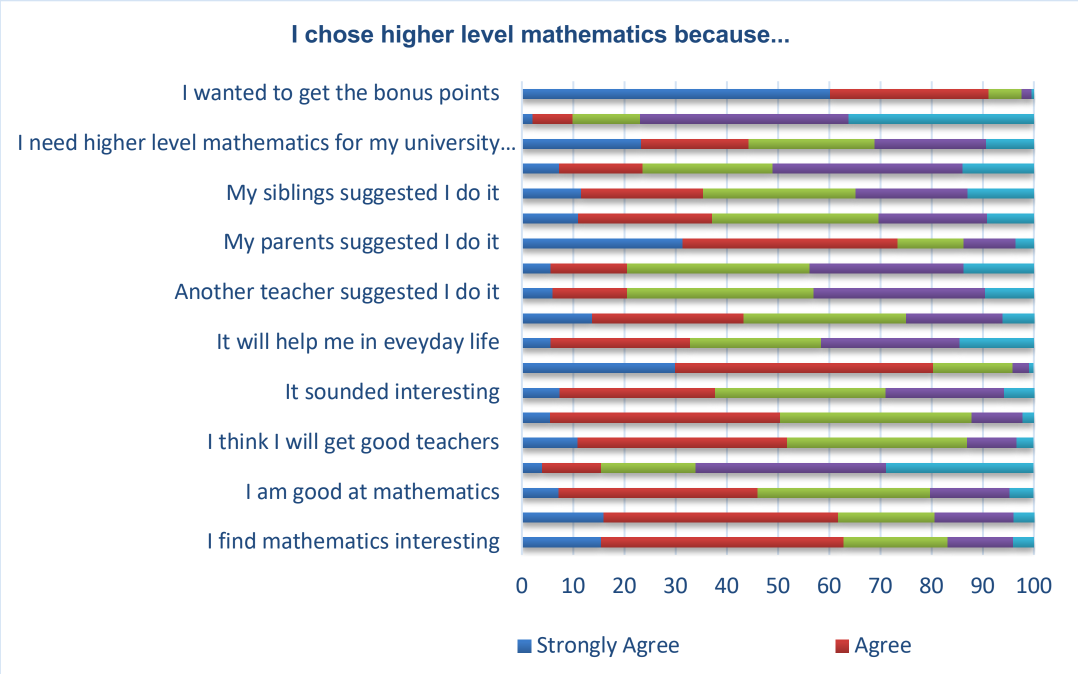

Figure 1: Percentage level of agreement with the different reasons for studying higher-level mathematics (N=911)
See Appendix A for full breakdown of percentages
(use web reader 'zoom in' function to facilitate reading)

Students were also asked to outline what they believed to be the most influential factor out of the nineteen that were listed. The top five most influential factors are presented in Table 3. In total 893 students offered a response to this question and almost half of these students, 46.2% (*n* = 413), indicated that of all the reasons listed, bonus points were the most influential factor in their decision. A further 7.2% (*n* = 64) stated that the CAO points on offer was the determining factor. This indicates that the majority of students, over half of those who responded, cited externally motivating factors, related to the CAO points system (CAO, n.d.), as the main reason they decided to pursue higher-level mathematics. In addition to this, a further 8.5% of students gave an answer of "other" or cited more than one reason when asked to outline the most influential factor in their decision. Students who gave such answers were asked to elaborate and analysis of this qualitative data showed that of the 76 students in this category, 58 offered more than one factor, and 93.1% (*n* = 54) of these responses included a reference to bonus points (*n* = 35) and CAO points (*n* = 19).

Table 3: Top five reasons for studying higher-level mathematics as reported by students

Reason	No. of responses
I wanted to get the bonus points	413
I need higher level mathematics for my university course	84
I like mathematics	77
Other/Cited 2+ factors	76
I will get good CAO points from it	64

On the other hand, analysis of the responses to this question also highlighted how only 4.4% of respondents stated that they chose higher-level mathematics primarily because they found it interesting; 5.9% stated that they chose higher-level because they are good at mathematics, while a mere 0.7% of respondents said they opted for higher-level mathematics because the skills developed in this course will help them in their everyday life. This indicates that intrinsic motivation did not really play a significant role in the majority of students' decision to pursue higher-level mathematics, with the exception of the 77 students (8.6%) who stated that the predominant reason which influenced their decision to study mathematics as this level was because they "*liked the subject*".

In order to address the second research question, the authors sought to determine if the reasons for studying higher-level mathematics differed across gender, school type, and prior attainment. In order to conduct this analysis the authors first had to determine the average mean score for each of the groups. In the survey a score of one meant that the student strongly agreed that the reason given was influential in their decision to pursue higher-level mathematics while a score of five indicated that they strongly disagreed. As such, a lower mean score for any given statement meant higher levels of agreement with that statement while a higher mean score indicated lower levels of agreement, meaning that factor was less influential in their decision to study higher-level mathematics. The results of this analysis are presented in Table 4.

Table 4 first shows that for gender, of the 19 reasons provided in the questionnaire, significant differences between the levels of agreement offered by males and females were recorded in nine of the statements. Some of the most notable differences were recorded for the statements *"I need higher level mathematics for my university course"* and *"I think I will get good marks"*. The average male score for *"I need higher level mathematics for my university course"* was 2.50 (s.d. = 1.27) while the median score among this cohort was 2. The corresponding mean among female students was 2.94 (s.d. = 1.27) while the median was 3. As the data for this response was not normally distributed and the data was ordinal, a Mann Whitney U test was carried out to determine if the differences recorded were statistically significant. This test showed that the male score was significantly lower than the female score (U = 80627, $p < 0.001$), meaning that male students were more likely to agree with this statement.

Table 4: Differences in responses across gender, school type and Junior Cycle grade
Results in bold are where the differences recorded were found to be significant
(use web reader 'zoom in' function to facilitate reading)

Item	Gender			School type			Junior Cycle grade		
	Male Mean (s.d.)	Female Mean (s.d.)	Sig. *p*	Second. Mean (s.d.)	Vocat. Mean (s.d.)	Sig. *p*	>70% Mean (s.d.)	<70% Mean (s.d.)	Sig. *p*
I find maths interesting	2.39 (1.01)	2.46 (1.03)	0.247	2.47 (1.06)	2.35 (0.95)	0.192	**2.21 (0.97)**	**2.77 (1.03)**	**<0.001***
I like maths	2.45 (1.03)	2.47 (1.08)	0.791	2.47 (1.07)	2.44 (1.05)	0.694	**2.19 (0.99)**	**2.89 (1.05)**	**<0.001***
I am good at maths	**2.57 (0.93)**	**2.86 (0.98)**	**<0.001***	2.73 (0.99)	2.68 (0.92)	0.663	**2.40 (0.89)**	**3.25 (0.87)**	**<0.001***
Maths is my best subject	**3.67 (1.12)**	**3.90 (1.74)**	**0.016***	3.83 (1.66)	3.72 (1.11)	0.428	**3.53 (1.70)**	**4.22 (0.85)**	**<0.001***
I think I will get good teachers	**2.43 (0.89)**	**2.63 (0.94)**	**0.001***	2.55 (0.95)	2.51 (0.88)	0.727	2.56 (0.94)	2.49 (0.90)	0.331
I think I will get good marks	**2.43 (0.76)**	**2.73 (0.89)**	**<0.001***	2.63 (0.86)	2.51 (0.76)	0.089	**2.40 (0.79)**	**2.88 (0.80)**	**<0.001***
It sounded interesting	2.83 (1.00)	2.95 (1.04)	0.110	2.90 (1.05)	2.89 (0.99)	0.986	**2.79 (1.04)**	**3.09 (0.98)**	**<0.001***
I will get good CAO points	1.89 (0.79)	2.00 (0.83)	0.051	**1.99 (0.82)**	**1.87 (0.78)**	**0.045***	**1.79 (0.74)**	**2.19 (0.86)**	**<0.001***
It will help me in everyday life	3.19 (1.21)	3.17 (1.09)	0.800	3.16 (1.16)	3.20 (1.13)	0.588	**3.10 (1.11)**	**3.31 (1.19)**	**0.008***
My Junior Cycle maths teacher suggested I do it	2.72 (1.07)	2.75 (1.13)	0.701	**2.63 (1.10)**	**2.92 (1.08)**	**<0.001***	**2.60 (1.10)**	**2.97 (1.05)**	**<0.001***
Another teacher suggested I do it	**3.21 (0.97)**	**3.31 (1.06)**	**0.046***	3.26 (1.03)	3.26 (1.00)	0.893	3.21 (1.03)	3.35 (0.98)	0.086
The career guidance teacher suggested I do it	**3.24 (1.06)**	**3.39 (1.06)**	**0.013***	3.30 (1.09)	3.33 (1.02)	0.819	**3.24 (1.09)**	**3.42 (1.03)**	**0.024***
My parents sugg-ested I do it	2.09 (1.03)	2.16 (1.12)	0.705	2.07 (1.06)	2.21 (1.09)	0.055	**2.09 (1.10)**	**2.19 (1.03)**	**0.039***
My friends sugg-ested I do it	2.94 (1.09)	2.89 (1.17)	0.460	2.87 (1.15)	2.97 (1.09)	0.165	2.90 (1.17)	2.93 (1.06)	0.996
My siblings sug-gested I do it	3.03 (1.12)	2.99 (1.26)	0.783	2.99 (1.22)	3.03 (1.17)	0.562	3.00 (1.22)	3.01 (1.18)	0.969
All my friends were doing it	**3.21 (1.10)**	**3.45 (1.14)**	**<0.001***	3.35 (1.13)	3.31 (1.12)	0.486	3.33 (1.14)	3.38 (1.10)	0.726
I need higher le-vel maths for my uni. course	**2.50 (1.27)**	**2.94 (1.27)**	**<0.001***	2.71 (1.28)	2.75 (1.30)	0.726	**2.61 (1.31)**	**2.94 (1.23)**	**<0.001***
It doesn't seem like it would be too much work	**3.19 (1.09)**	**4.11 (0.89)**	**0.023***	4.04 (0.97)	3.96 (1.04)	0.375	**3.96 (1.00)**	**4.11 (0.96)**	**0.015***
I wanted to get the bonus points	1.47 (0.66)	1.55 (0.80)	0.456	1.50 (0.72)	1.53 (0.77)	0.485	**1.56 (0.73)**	**1.48 (0.75)**	**0.048***

For the second statement, *"I think I will get good marks"* the mean score for males was 2.42 (s.d. = 0.76; median = 2) while the mean score among females was 2.73 (s.d. = 0.86;

median = 3). In this instance the responses were normally distributed but because the dependent variable was ordinal, a *t*-test was not appropriate and so a Mann Whitney U test was again conducted to determine if the differences recorded were statistically significant. This test showed that again the differences recorded were statistically significant (U = 80860.5, $p < 0.001$). This indicates that males were more likely to agree with this statement than their female counterparts.

Another finding to emerge when results were compared across gender was that for all the reasons relating to self-efficacy (e.g., *I study higher level mathematics because I am good at maths* or *I study higher level mathematics because maths is my best subject*) males recorded a significantly lower average score than females. This is despite the fact that female students actually achieved slightly better grades in their Junior Cycle exam. For example, 62.4% of females in the sample achieved over 70% in their Junior Cycle mathematics examination compared to 61.9% of males reaching this threshold. While this difference in performance is not significant, it is interesting to note that even though females performed equally as well, and in some cases better, than their male counterparts in prior state examinations, males' demonstrated higher self-belief in relation to their mathematical performance and this played a role in their choice to pursue higher-level mathematics.

When the results were compared across school type two significant differences were recorded. Firstly, students who attended secondary schools were more likely to cite their teacher as having an influence on their decision to study higher-level mathematics. The average secondary school student score for *"My Junior Cycle mathematics teacher suggested I do it"* was 2.63 (s.d. = 1.10) while the median score among this cohort was 3. The corresponding mean among students attending a vocational school was 2.92 (s.d. = 1.08) while the median was also 3. A Mann Whitney U test was again deemed appropriate to determine if the differences recorded were statistically significant. This test showed that the scores for those attending secondary schools were significantly lower than the scores for those attending vocational schools (U = 82750.5, $p < 0.001$). Secondly, the CAO points system in place in Ireland (CAO, n.d.) appears to be more influential for vocational school students compared to secondary school students. The mean score for the statement *"I will get good CAO points from it"* for vocational school students was 1.87 (s.d. = 0.78) compared to a mean of 1.99 (s.d. = 0.82) for secondary school students. Using a Mann Whitney U test, this difference was found to be significant (U = 90273.5, $p = 0.045$). This indicates that while secondary school students reported teachers to be a greater influence on their decision to pursue higher-level mathematics compared to their peers attending vocational schools, the CAO points system (CAO, n.d.) was found to be a greater driving factor for vocational school students.

The final comparison that the authors wished to conduct was in relation to prior attainment. For this, the sample was split into two mutually exclusive groups based on the grade they were awarded for their Junior Cycle mathematics exam, i.e., Group 1 was made up of students who scored over 70% in the Junior Certificate higher-level examination while Group 2 was made up of students who scored less than 70% on the higher-level paper or opted for the ordinary-level paper at Junior Cycle. Statistically significant differences in mean scores were recorded for fourteen of the nineteen statements. The mean scores of students in Group 1 were significantly lower for the three reasons associated with self-efficacy towards mathematics (*"I am good at mathematics"*, *"Mathematics is my best subject"* and *"I think I will get good marks"*) thus indicating that these reasons resonated more so with them than students who achieved less than 70% or sat the ordinary level paper at Junior Cycle. A similar scenario emerged when reasons relating to positive dispositions towards mathematics were considered. For example, for the statement *"I find mathematics interesting"* the mean score for Group 1 students was 2.21 (s.d. = 0.97) compared with a mean of 2.77 (s.d. = 1.03) for lower achieving students. This difference was found to be statistically significant (U = 65030.5, $p < 0.001$). Similar results were noted for the statement *"I like mathematics"*.

On the other hand, it was interesting to note that the only reason that students in Group 2 were more in agreement with was *"I wanted to get the bonus points"*. Their mean score for this statement was 1.48 (s.d. = 0.75) compared with a mean of 1.56 (s.d. = 0.73) for those who achieved over 70%. These findings combined indicate that those who excelled in Junior Cycle mathematics were more intrinsically motivated to undertake higher-level mathematics at Senior Cycle, whereas extrinsic motivation was more prevalent among those who achieved less than 70%. Finally, this was the only comparison test which yielded a significant difference in relation to the role of parents in students' decision to pursue higher-level mathematics. The authors discovered that students in Group 1 students were more likely to agree that their parents had a role in their decision to study higher-level mathematics compared to their peers who did not perform as well in the Junior Cycle examination. These results were again found to be significant (U = 85772.0, $p = 0.039$).

Conclusions and recommendations

The first research question sought to determine the influential factors in students' decision to pursue higher-level mathematics. The findings have shown the true extent of the influence of the bonus points initiative on students' decision to study mathematics in its most advanced form. While recent studies have suggested that this was the case (O'Meara et al., 2020), this is the first study that has definitively shown the influence of this initiative and the authors hypothesise that without the bonus points it is highly likely that the proportion of students studying higher-level mathematics would be drastically lower. Thus, the BPI has achieved its aim of increasing the numbers studying higher level mathematics in Ireland. However, this has not been without consequences and there have been many 'side-effects'. For example, the O'Meara et al. (2020) determined that the increase in participation has not resulted in a simultaneous increase in mathematical attainment. With the CAO points system (CAO, n.d.) acting as the driving force, students are pursuing higher-level mathematics despite struggling hugely with the content (O'Meara et al., 2020). This presents many challenges to students and teachers alike and so the authors recommend that policy makers look at other initiatives to improve students' attitudes towards mathematics in lower secondary school, in the hope that intrinsic reasons such as liking mathematics or having a deep-rooted interest in the subject will play a more influential role in students' decision to study higher-level mathematics in the future. This call to develop initiatives to raise students' intrinsic motivation to study mathematics is in line with calls made by researchers internationally (Mujtaba, Reiss & Hodgson, 2014) and is something that needs to be initiated across both primary and post primary level.

This study's finding that students are predominantly extrinsically as opposed to intrinsically motivated to study higher-level mathematics is further cause for concern, due to research findings in relation to the role of extrinsic motivation. It appears that extrinsic motivators, in this case the CAO points system (CAO, n.d.) and the provision of bonus points, do not work over time (Adamma, Ekwutosim & Unamba, 2018). In fact, the presence of extrinsic motivational factors can lead to diminished intrinsic motivation among students (Biehler & Snowman, 1990). Therefore, the role that the bonus point initiative is currently playing in motivating students to study higher-level mathematics may have negative effects on students' affective reaction to the subject. This means that in the future, if the bonus points are removed completely, as has been advocated by some teachers (O'Meara et al., 2020), Ireland may see a lower proportion of students opt for higher level mathematics than was the case when the Irish Government first set about rectifying this issue in 2012.

This study also sought to determine if gender, school type or prior attainment affected students' reasoning for studying higher level mathematics. In relation to gender, the results showed that males were more likely to suggest that their perceived ability in mathematics and their liking of the subject was a reason behind their decision to study higher-level mathematics compared to females. While research has pointed to differences in attitudes towards mathematics across gender (Frenzel, Pekrun & Goetz, 2007; Casey & Ganley, 2021) for many years, this study shows that these differences are contributing to students' decision to study higher-level mathematics. Sheldrak, Mujtaba and Reiss (2014: 462) found that *"Students' self-beliefs of ability influenced… their intended and actual subject choices…"* and in Ireland this seems to be true for male students and could help explain the fact that the proportion of males opting to study higher-level mathematics in Ireland was approximately 2.8 percentage points more than that of females in both 2018 (33% of males compared to 30% of females) and 2019 (34.2% of males compared to 31.8% of females). Such findings lead the authors to believe that, going forward, it is very important that efforts are made to improve female students' attitudes and self-efficacy in relation to mathematics in the hope that this will have a knock-on effect on female students' opting to study higher-level mathematics.

One area where the authors did not witness a significant difference between male and female responses was in relation to the role of teachers in the decision-making process. In physics, Mutjaba and Reiss (2014) found that boys were more inclined to report that they are encouraged to continue with physics post-16 by their teachers, compared to girls, but similar findings did not emerge in this study in relation to mathematics. Where differences were noticed in this category was between school types. Students attending secondary schools were more likely to report that their Junior Cycle teacher encouraged them to continue their study of higher-level mathematics at Senior Cycle compared with students who were attending a vocational school. Given that Mutjaba and Reiss (2014: 384) found

"…*that teachers' encouragement of individual students to continue with physics post-16 was the item that associated most strongly with intended participation*", it is unsurprising that a greater proportion of students from secondary schools (56.1%) pursued higher-level mathematics compared to those who attended vocational schools (49.1%). This is despite the fact that comparable proportions in both settings received over 70% in their Junior Cycle mathematics exam.

Finally, this study sought to determine if prior achievement played a role in students' reasons for studying higher-level mathematics in Ireland. Mujtaba and Reiss (2016) found that families were more influential in male students' decision to pursue mathematics post-16 in the UK but similar findings were not found in this study. However, there was found to be a significant difference in this regard between students who achieved over 70% in their Junior Certificate exam and those who achieved below 70% or sat the ordinary level paper. This study found that high achievers were more likely to be encouraged by their parents and teachers to study higher-level mathematics while lower achieving students did not believe these actors played as significant a role in their decision. This was one of 14 significant differences recorded when comparing these two groups, with higher achieving students more likely to be in agreement with 13 of these 14 reasons as being influential for undertaking higher-level mathematics. For those who achieved less than 70% in the Junior Cycle exam there was one statement of the 14 that they were in stronger agreement with and that was in relation to the availability of bonus points. Despite Mutjaba, Reiss and Hodgson's (2014) finding that in London prior attainment was not an influential factor in students' decision to pursue mathematics once it was no longer compulsory, the findings from this study suggests that prior attainment is one of the biggest influences on students' reasons to pursue higher-level mathematics. However, it seems that the external factor of bonus points is a driving factor in this and without the availability of bonus points lower achieving students would be much less likely to opt for higher-level mathematics. It is therefore even more important to consider ways to enhance this cohort's intrinsic motivation to study higher-level mathematics.

One way that has been shown to do this effectively is by highlighting the utility-value of mathematics to students who struggle with mathematics (O'Meara et al., 2022). Hence, it is critical that all students are exposed to real-life applications of mathematics in lower secondary school in a bid to help them appreciate the power, value and beauty of mathematics. Another recommendation to stem from this finding is in relation to the current structure of the BPI. The allocation of the same number of additional points once a student reaches the 40% threshold in the Leaving Certificate exam seems to be motivating students who may have struggled with mathematics at Junior Cycle to attempt it in the hope that they will just make the grade necessary to achieve the bonus points on offer. In light of this, the authors would encourage policy makers to review the BPI and to consider the introduction of bonus points on a scaled basis, meaning those achieving higher grades (e.g., H1/H2) would receive a greater number of bonus points than those receiving lower grades at higher-level. This scaling would mean that the BPI would not be as much of an incentive for those students who may be best suited to ordinary level mathematics but take a calculated risk in the hope of passing at higher level.

To conclude, this study is the first of its kind in Ireland to attempt to determine the reasons influencing students' decision to pursue higher-level mathematics. It has revealed that students are predominantly extrinsically motivated to study advanced mathematics and this has been exacerbated by the recent introduction of the BPI. Research has shown that when external factors play such a significant role in students' decision-making processes there is a risk that they begin to overlook internal factors, such as an enjoyment or appreciation for mathematics, in their decision making. This was never an intended outcome of the BPI and this paper offers some suggestions for policy makers and educators in relation to how they might be able to reverse this trend so that Irish students are more intrinsically motivated to study mathematics. This study could also, therefore, serve as a warning call to other countries looking to incentivise the study of advanced or higher-level mathematics and the authors have offered some suggestions regarding more effective incentive schemes that may allow jurisdictions to reap the benefits of the BPI experienced in Ireland without experiencing the drawbacks that have been reported by teachers.

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Appendix 1: Percent agreement with the different reasons for studying higher-level mathematics

Reason	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I find mathematics interesting	15.5	47.4	20.3	12.8	4.0
I like mathematics	16	45.8	18.8	15.5	4.0
I am good at mathematics	7.2	38.9	33.7	15.5	4.6
Mathematics is my best subject	4	11.5	18.5	37.2	28.7
I think I will get good teachers	10.9	40.9	35.2	9.7	3.2
I think I will get good marks	5.5	45	37.4	9.9	2.2
It sounded interesting	7.4	30.4	33.3	23.1	5.9
I will get good CAO Points from it	30	50.3	15.6	3.2	0.8
It will help me in everyday life	5.6	27.3	25.6	27	14.5
My Junior Cycle mathematics teacher suggested I do it	13.7	29.6	31.8	18.8	6.2
Another teacher suggested I do it	6	14.6	36.4	33.5	9.5
Career guidance teacher suggested it	5.6	15	35.6	30.1	13.7
My parents suggested I do it	31.4	42	12.9	10.2	3.5
My friends suggested I do it	11	26.2	32.5	21.2	9.1
My siblings suggested I do it	11.6	23.8	29.8	21.9	12.9
All my friends were doing it	7.3	16.3	25.4	37.1	13.9
I need higher level mathematics for my university course	23.3	21	24.6	21.8	9.3
It doesn't seem like it would be too much work	2.1	7.8	13.2	40.7	36.2
I wanted to get the bonus points	60.2	31	6.4	2	0.4

Dr Niamh O'Meara (corresponding author) is a lecturer in mathematics education in the University of Limerick and deputy director of EPISTEM, the National Centre for STEM Education. She is a qualified mathematics teacher and her research interests include teacher knowledge, curricular issues in mathematics education and improving attitudes and performance in mathematics.
Email: niamh.omeara@ul.ie

Dr Mark Prendergast is a senior lecturer in mathematics education in the University College Cork. He is a qualified secondary level mathematics teacher and his research interests include teacher education, mathematics education, and working with non-traditional students.
Email: mark.prendergast@ucc.ie

Dr Páraic Treacy is a Lecturer in Mathematics at Mary Immaculate College (Thurles). His qualifications include a PhD in Mathematics Education, BSc in Physical Education and Mathematics, and a Senior Fellowship of the HEA (UK). His research interests include integrating mathematics with other subjects; mathematics curriculum change; and student transition from second to third level mathematics study.
Email: paraic.treacy@mic.ul.ie

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