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High achievement in mathematics and science: A chronology of relevant educational policy and findings from large-scale assessments in Ireland, 1995 to the present day

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Abstract

Save for the 2009 Programme for International Student Assessment (PISA) shock, Ireland has recorded strong average scores in mathematics, science, and reading on national and international large-scale assessments. Despite this, percentages of high achievers in mathematics and science in these assessments have remained stubbornly lower than those of some countries with average performance similar to that of Ireland. Reflecting the multifaceted benefits to individuals and society of knowledge and skills in science, technology, engineering, and mathematics (STEM), increasing prioritisation in educational policy in Ireland of high achievers in mathematics and science over the past decade in particular is not unexpected, albeit this was not always the case. This paper offers a chronology of Irish educational policy documents since 1995 illuminating why, when, and how high achievement in mathematics and science has emerged as a key component and driver of educational policy reform.

Keywords: high achievement, national assessments, international assessments, mathematics, science, educational policy

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Researchers (e.g., McKeown et al., 2019; Perkins & Clerkin, 2020) have observed that while Ireland's results in a number of national and international large-scale assessments indicate that, on average, students perform well in mathematics and science, there are low proportions of high-achieving students (i.e., those who score at the highest

proficiency levels) in these two subjects. Further, the scores of students in Ireland performing at the highest national percentiles in these subjects have tended to be lower than those of their counterparts in countries with similar average performance. Some similar patterns of decreases in the percentages of high achievers in mathematics and science-related subjects in the Junior and Leaving Certificate examinations have also been detected over the last 15 years (e.g., Pitsia, 2021; Shiel et al., 2020).[1] In this context, it is interesting that, while Ireland has consistently scored very highly in reading in both national and international large-scale assessments, for the most part, patterns with regards to high achievement in reading have not been similar to those found in mathematics and science.

Writing in 2012, Roberts noted the increasing prominence being afforded to knowledge and expertise in the allied fields of science, technology, engineering, and mathematics (the STEM subjects), opining that 21st-century learners would be "…required to exhibit understanding and skills that were unfathomable to us just twenty years ago" (Roberts, 2012, p. 4). Indeed, the importance of STEM knowledge and expertise for personal, social, professional, and economic development and advancement has been increasingly recognised by many countries, including Ireland (Business Roundtable & Change the Equation, 2014; Department of Education and Skills [DES], 2017e, 2017d; Government of Ireland, 2018; Nugent et al., 2015).

Further, as this paper outlines, the current prioritisation of STEM in Irish policy documents reflects a shift in focus at government level from initial concern with low achievement in literacy and numeracy to an increasing awareness of, and commitment to, addressing the needs of higher-achieving students in mathematics and science. Invariably, as observed by McLaughlin (2008), "…problem framing – what a policy concern is assumed to be a 'problem of' – arguably is the most important decision taken as a policy is developed" (p. 176) because it sets the stage for what gets attention and what is side-lined at the point of implementation. As this paper documents, the needs of high-achieving students in mathematics and science, albeit increasingly acknowledged in national policies, have yet to be addressed comprehensively – perhaps because they are not seen to *present a problem*. While not advocating such an interpretation, this paper aims to highlight a sustained 'sin of omission' on the part of the Irish education system to high achievers that requires urgent redress.

1995–1998: White Paper on Education and Education Act

The mid-1990s is recognised as a watershed period in Irish education. Publication of the seminal policy document "*Charting our Education Future: White Paper on*

1 The introduction of the *Bonus Points Scheme* for students taking Leaving Certificate mathematics at higher level in 2012, the subsequent increases in the proportions of students taking Leaving Certificate mathematics at higher level, the transition to a new grading system for the Leaving Certificate examination in 2017, and the transition to a common-level examination for Junior Certificate science in 2019 should be taken into consideration in interpreting such decreases.

Education" by the Department of Education (then the Department of Education and Science [DES]) in 1995 marked a period of intense, consultative debate amongst key stakeholders. As framed, the White Paper constituted a comprehensive policy agenda for change reflective of an acknowledged need by the educational partners to review achievements and "chart future directions" (DES, 1995, p. 1) in light of emerging trends in educational provision and practice. Both the *1995 White Paper* and the *1998 Education Act* that followed set a very ambitious and inclusive tone and committed to providing for "…every person in the State, including any person with a disability or who has other special educational needs" across primary, post-primary, adult and continuing education and vocational education and training (Government of Ireland, 1998, p. 5); however, neither made explicit reference to performance in mathematics and science or, indeed, high achievers. Rather, enabled by the provision of higher-, ordinary-, and foundation-level examinations for both Leaving Certificate and Junior Certificate post-primary students, a commitment was made to "…encouraging students to follow courses at the highest level indicated by their capacity, thus challenging them to develop their potential" (DES, 1995, p. 52).

2001–2008: Participation in National and International Large-Scale Assessments and the Project Maths Initiative

Following Ireland's inaugural administration of the Programme for International Student Assessment (PISA) in 2000, the *Chief Inspector's Report for the period 2001-2004* (DES, 2005a) was among the first government documents to explicitly address Ireland's involvement in international large-scale assessments. Summarising the PISA 2003 results (the then latest cycle of PISA), when mathematics was the major assessment domain, emphasis within the report was on low achievers with no explicit reference to high achievement in any of the PISA subjects (mathematics, science, reading). Indeed, it was not until Cosgrove et al. (2005) and Surgenor et al. (2006), respectively, reported on Ireland's performance in PISA 2003 and the 2004 National Assessments that a set of recommendations in relation to mathematics education at primary and post-primary levels included a focus on high-achieving students. Noting that, on average, high achievers in Ireland tended to underperform compared to their counterparts in other countries, the authors highlighted the need for schools and classes to make specific provision for these students.

Although the authors of the national PISA 2003 report and the report on the 2004 National Assessments did not elaborate on these findings and recommendations, this marked an important turning point subsequent to which state agencies such as the National Council for Curriculum and Assessment (NCCA) commissioned research (e.g., Conway & Sloane, 2005) on international trends in mathematics education that reiterated the need to address issues relating to high achievement in Ireland. This momentum was sustained with the publication of a teachers' guide informed by PISA

2003 data by Shiel et al. (2007) in which the authors noted that "…higher-achieving students (those scoring at the 90th percentile) achieved a score that was 14 points lower than the OECD (Organisation for Economic Co-operation and Development) average score at that benchmark. Hence, while low-achieving students in Ireland did reasonably well, higher achievers underperformed relative to students elsewhere" (p. 46).

Shiel et al.'s (2007) publication was followed, in 2008, by the phased implementation of the Project Maths initiative, introduced in 24 schools initially, and the development of revised syllabi in both Junior and Leaving Certificate mathematics (DES, 2010a). As reported (see Lubienski, 2011), however, although impressive in many aspects including its clear vision, and phased, collaborative approach to implementation characterised by strong teacher engagement, there was no explicit attention to high achievers in mathematics in the programme, a shortcoming noted by the Project Maths Implementation Support Group in its 2010 report. Despite the success of the project (it was extended to all schools in Ireland in 2010, with full implementation completed by 2015), the Support Group noted that although it was beyond their remit "…to develop a programme to meet these students' needs…their talents should be capitalised on" (DES, 2010b, p. 36). Once again, although the specific needs of this cohort of students were acknowledged, no specific recommendations on how those might be addressed were provided.

2009: PISA Shock

From a policy perspective, the announcement of the PISA 2009 results marked a very significant moment in Ireland: results pointed to an unprecedented dip in performance with fewer high-achieving students in mathematics and reading compared to previous PISA cycles and a relatively larger decline in reading performance (Perkins et al., 2010). As argued (e.g., Froese-Germain, 2010; Gorur, 2016; Hopkins et al., 2008), unexpectedly negative performances of this kind often prompt shockwaves within countries generating a period of significant policy reform.

In scrutinising Ireland's *shock* (Ertl, 2006; Heyneman & Lee, 2014), Perkins et al. (2012), Cosgrove and Cartwright (2014), and Cosgrove (2015) hypothesised that certain factors could be linked with Irish students' underperformance. Amongst the explanations cited were students' reduced engagement during PISA testing and changes in the content and structure of the PISA tests across cycles (e.g., number of link items used). Cosgrove and Cartwright (2014) also noticed a larger increase in missing data for Ireland between 2003 and 2009 compared to the rest of the OECD countries. Another finding by the same authors, which was also unique to Ireland, was that along with the increase of missing data for items in the last block position (i.e., the block of questions with which each student was presented last), there was a decline in the percentage of correct item responses but not an increase in incorrect responses, with this pattern being more pronounced for the link items compared to the new items. Taking this

evidence into account, Sachse et al. (2019) examined the potential impact of missing data on estimates of performance in international large-scale assessments using Ireland's PISA 2009 dip as a case study. The authors showed that this large decline, especially in reading, was reduced when performance trends were estimated while accounting for changes in missing data mechanisms and percentages of missing data. This indicated that Ireland's 2009 underperformance could be linked to the way missing data were scored (e.g., omissions being scored as wrong) and included into the estimation of performance and not necessarily to other external factors. Although Ireland's PISA shock triggered research on the factors linked to students' mathematics and reading performance, for the most part, issues relating to high achievement were, once again, side-lined in research and the policy changes that followed.

2011: National Strategy to Improve Literacy and Numeracy

The introduction in 2011 of the *National Strategy to Improve Literacy and Numeracy* (DES, 2011a) was described by the Chief Inspector as "ground breaking for the Irish system" (Hislop, 2013, p. 8). As detailed elsewhere (e.g., Lysaght & O'Leary, 2017), in Ireland, greater accountability is often accompanied by a commitment to evidence-based or evidence-informed policy. In the case of the *Literacy and Numeracy Strategy*, as the policy is colloquially known, this represented the Irish government's first articulation of nation-wide targets in relation to high achievement in mathematics at primary and post-primary levels. Amongst the 41 actions set out across six pillars of the education system, almost 180 sub-actions were identified linked with a series of targets to be achieved during the course of the *Strategy* implementation to 2020. At primary level, a target set was to increase the proportion of second- and sixth-class students performing at the two highest levels in the National Assessments of Mathematics and English Reading (NAMER) to 40%, respectively, by 2020. At post-primary level, within the same timeframe, the goals set included increasing the percentage of (a) 15-year-old students performing at or above proficiency level 4 in PISA mathematics tests by at least five percentage points, (b) students taking the higher-level mathematics examination in the Junior Certificate examination to 60%, and (c) students taking the higher-level mathematics examination in the Leaving Certificate examination to 30 percent. Referred to as "novel" by the Chief Inspector (Hislop, 2013, p. 8), the articulation of specific targets - informed and measured by trends in Ireland's performance in international large-scale assessments - represented a radical departure in Irish educational policy. In reality, as the DES acknowledged "… the public and political interest aroused by PISA [2009]…deepened… interest in how well students [were] learning…" leading to "…a commitment to tackling long-standing issues" (Hislop, 2011, p. 7).

History evidences the significant and far-reaching influence of the *Literacy and Numeracy Strategy* on subsequent educational policy in Ireland not least in relation

to high achievement in mathematics and science. For example, in contrast to the *DES Strategy Statements for the period 2005-2010* (DES, 2005c; 2008), following the introduction of the main national targets for high achievers in PISA and NAMER, subsequent policies saw these targets extended to include new targets also referring to science. Under its first major goal (to "…provide a quality inclusive school and early years education system with improved learning outcomes" [DES, 2011b, p. 6]), the *DES Strategy Statement* for the period 2011-2014 identified increasing the proportion of high achievers and the enhancement of student performance at the highest national percentiles on national and international large-scale assessments in Ireland as key policy targets.

2012: Higher Education Institutions' Bonus Points Scheme

Concomitant with developments at primary and post-primary levels, 2012 saw the introduction by Higher Education Institutions in Ireland of a *Bonus Points Scheme* for students taking Leaving Certificate mathematics at higher level. Students who achieve grades D3 or 6 and above in the old and new grading systems, respectively, are awarded 25 extra points (Central Applications Office, 2012). Conceived as an incentive scheme, the objective was to increase the numbers of students taking the Junior and Leaving Certificate mathematics examinations at higher level. Together with the roll out of Project Maths in schools, the overarching ambition of the scheme was to support the achievement of the national targets set in the *2011 Literacy and Numeracy Strategy*. Indeed, research has shown that the *Bonus Points Scheme* has contributed to increases in the proportions of students taking Leaving as well as Junior Certificate mathematics at higher level, reaching the target of 30% for Leaving Certificate mathematics, as set in the *Interim Review Report of the 2011 Literacy and Numeracy Strategy* to be achieved by 2020, ahead of schedule (DES, 2017e; Pitsia, 2021; Shiel et al., 2020). It is important, though, to highlight that the *Bonus Points Scheme* and the Project Maths initiative were introduced close to each other and, thus, it is difficult to gauge any potential effects of the former on the performance of students in the Leaving Certificate examination, as any effects could also be attributed to the latter or other reforms and/or changes in the Irish education system during the same period. Additionally, despite both initiatives showing some promising outcomes and evidencing increased policy focus on mathematics education in Ireland, it is noteworthy that neither focused specifically on high-achieving students as a defined cohort.

2013–2017: Reforms in STEM Education

Increased interest in high achievement in mathematics and science in 2011 and 2012 policy documents coincided with efforts to raise interest and introduce reforms in STEM education in Ireland. To achieve a whole-of-system approach to strategic planning and implementation across the education system and the workplace, the DES developed

a number of key national education and training initiatives. These initiatives, though not specifically focused on high achievement in mathematics and science per se, were underlined by an acknowledgement that the provision of meaningful, enjoyable, and appropriately challenging student learning experiences within STEM is contingent on the creation of a supportive STEM ecosystem in Ireland in which stakeholders work collaboratively towards developing a connected learning network (DES, 2011a, 2017e).

Along with the *National Literacy and Numeracy Strategy*, two main initiatives paved the way for developments in STEM education in Ireland: (a) establishment of the STEM Education Review Group in 2013 (The STEM Education Review Group, 2016) and (b) the *Policy Statement on STEM education 2017-2026* (DES, 2017e). The former undertook a comprehensive review of STEM education in Irish schools, while the latter provided challenging proposals for STEM education in Ireland across three phases between 2017 and 2026 with both acknowledging the importance of mathematical and scientific knowledge and skills as foundational STEM disciplines. Arising from these initiatives, STEM has secured a central policy focus at all education levels in the Irish education system (DES, 2017c; The STEM Education Review Group, 2016).

The *Report of the STEM Education Review Group* raised concern regarding the relatively low proportions of Irish primary and post-primary students performing at the highest proficiency levels in national and international large-scale assessments, especially in mathematics. They also highlighted that Ireland's outcomes in STEM subjects overall across national and international assessments were disappointing given the country's stated ambition to meet the needs of all learners and meet its future economic targets (The STEM Education Review Group, 2016). Accordingly, the Review Group argued for changes in STEM education in Ireland on the basis that the low proportion of high achievers and their consistently moderate performance in STEM-related subjects would potentially undermine future educational progress and economic prosperity.

In response to these patterns of performance, and towards advancing ambitions to becoming a European leader in the STEM disciplines by 2026 (*Policy Statement on STEM education*, DES, 2017e), increasing the proportion of students performing at the highest proficiency levels and the performance of students scoring at the highest national percentiles in mathematics and science became policy priorities in Ireland. Ambitious targets have also been set to ensure greater numbers of senior-cycle students taking higher-level state examinations in mathematics and science-related subjects as well as, more generally, to improve the skills of STEM graduates. For instance, as stated in the *Policy Statement on STEM education*, the uptake of STEM subjects in the Leaving Certificate examination for students of all backgrounds, ability, and gender and extra-curricular STEM activities in schools in every region has been set to increase by 20% until 2026 (DES, 2017e).

2015–2018: A Period of Numerous Policy Developments

A range of publications following the *2011 Literacy and Numeracy Strategy* reinforced Ireland's overarching ambition to create "…an internationally recognised education and training system based on evidence-informed policies designed to anticipate and respond to the changing needs of learners, society and the economy" (DES, 2015, p. 2).

Education and Training Sector Overview of Service Delivery and Reform Report and Action Plans for Education

The *DES 2015 education and training sector overview of service delivery and reform report* identified a number of "whole system reform" goals to include "…all learners, all teachers and all schools and colleges" (DES, 2015, p. 11), one of which was "improving quality and accountability" (p. 3). As envisaged, this was to be achieved by engaging a range of strategies including reform of initial teacher education, implementation of new models of school inspection, developing teachers as professionals, introduction of school self-evaluation and improvements of the assessment and reporting of students' progress (DES, 2015).

Echoing this, and building on the targets of the *Literacy and Numeracy Strategy*, the *DES Action Plan for Education 2016-2019* identified improvement of "…the learning experience and the success of learners", as its first major goal (DES, 2016a, p. 8). Again, it referred to increasing the percentages of students taking higher-level mathematics to 60% and 30% at the end of Junior Cycle and Senior Cycle, respectively, by 2020. In turn, the *Government of Ireland 2018 Action Plan* set increases in the percentages of students taking specified Leaving Certificate STEM subjects (i.e., chemistry, physics, technology, and engineering) to 20% (for the general student population) and 40% (for school-going females) by 2026 as a key target (Government of Ireland, 2018). With reference to performance in international assessments, an increase to 13% – 10% in the case of post-primary Delivering Equality of Opportunity in Schools (DEIS) schools – by 2020 in mathematics in the proportion of students achieving at proficiency level 5 or above in PISA has been set with an equivalent target for science of 10% by 2025 also earmarked. Save for identifying key reform initiatives in the *Overview of service delivery and reform* report (DES, 2015), a roadmap for how these targets were to be achieved remained elusive.

National Skills Strategy 2025

Ireland's National Skills Strategy 2025, published in 2016, constitutes another national initiative that is committed to assisting all individuals in reaching their full potential and contributing to the country's development in social, cultural, and economic terms (DES, 2016b). Within this strategy, former Minister for Education and Skills, Jan O'Sullivan

TD, and Minister for Skills, Research, and Innovation, Damien English highlighted that given Ireland's size, the country could not "…afford untapped talent…" nor could it "… leave any…people locked out of participating in the workforce through a lack of skills" (p. 7). This discussion focused on the utilisation of talent in STEM-related fields and, in particular, mathematics and science, highlighting the significance of these skills for individuals and society.

Interim Review Report of the 2011 National Strategy to Improve Literacy and Numeracy and DEIS Plan

In the *Interim Review Report of the 2011 Literacy and Numeracy Strategy* published in 2017, some of the original 2011 targets in relation to high achievement in mathematics, as mentioned above, were revisited (in some cases because they had already been achieved), while new ones were also introduced (DES, 2017b). Taking into account the then latest available data (i.e., NAMER 2014 and PISA 2015), the *Interim Report* updated the target for increasing the proportions of second- and sixth-class students performing at the two highest proficiency levels in NAMER set in the *2011 Literacy and Numeracy Strategy*, changing the expected percentages from 40% to 53% and 50% for second and sixth class, respectively. A new set of national targets not previously included in the *2011 Strategy* was also introduced in the *Interim Report*, reflecting policy initiatives developed in the intervening period. Specifically, the report included targets for high-achieving students in PISA - those achieving at or above proficiency level 5, as well as for those achieving at proficiency level 4 and higher. The targets pertaining to the proportions of students taking higher-level mathematics at the end of Junior and Senior Cycles as described in the *Action Plans for Education 2016-2019* and *2018* were also reiterated in the report (DES, 2016a, 2017b; Government of Ireland, 2018).

The identification of a gap in achievement between schools, especially primary schools, with the highest concentration of disadvantage (DEIS Band 1) and other schools within the context of the review of the *2011 Literacy and Numeracy Strategy* led to increased policy attention to high achievement for disadvantaged schools in Ireland. Even though national targets in relation to high achievement for all schools were set out in the *2011 Literacy and Numeracy Strategy*, as described above, in a time when the DEIS initiative had already been established to give tailored support to schools with a high concentration of disadvantage (see DES, 2005b), it was only after the review of the *Strategy* that explicit targets for high achievers in mathematics for DEIS schools were set. The *Interim Review Report of the 2011 Literacy and Numeracy Strategy* and the *DEIS Plan 2017* were the first policy documents to include these targets. Specifically, these targets indicated that the percentages of second- and sixth-class students in DEIS Band 1 schools performing at proficiency level 3 or higher in NAMER mathematics should increase to 30% and 27%, respectively, by 2020. It was also stated that percentages of 15-year-old students in DEIS schools performing at

or above proficiency level 4 in PISA mathematics should rise to 29% and at or above proficiency level 5 to 10% by 2020 (DES, 2017a, 2017b).

In the absence of initiatives and programmes specifically tailored to the needs of high achievers, it is difficult to gauge the extent to which national targets relating to high achievement formulated and subsequently revised in the context of the *2011 Literacy and Numeracy Strategy* have been realistic. This absence makes the realisation of these targets harder as they are not accompanied by a plan of action as to how they could be achieved. Besides this absence of tailored initiatives and programmes, the actual targets may also be characterised as too simplistic and unidimensional failing to capture the multifaceted nature of mathematical and scientific knowledge and skills. For instance, Ireland's data from various cycles of PISA and Trends in International Mathematics and Science Study (TIMSS) have shown that geometry, algebra, and space and shape items in mathematics tests as well as physics and chemistry items in science tests tend to be more difficult for both primary and post-primary Irish students compared to items from other content domains (e.g., McKeown et al., 2019; Perkins & Clerkin, 2020; Shiel & Kelleher, 2017). It could be the case that more specific targets reflecting these patterns, and subsequent initiatives and programmes, could be more relevant and, potentially, more feasible and meaningful for the Irish education system.

Policy Statement on STEM Education for the Period 2017-2026

The *Policy Statement on STEM education for the period 2017-2026*, also published in 2017, attempts to raise interest and introduce reforms in STEM education in Ireland. It states that Ireland's ambition is to become the best education and training service in Europe by 2026 (DES, 2017e). This aspiration was also highlighted in the *Action Plan for Education 2018* (Government of Ireland, 2018), setting out the deliberately ambitious educational agenda that Ireland has set for the near future. However, it was also acknowledged in the *Policy Statement* that given the growing needs for graduates with high skills and qualifications in STEM, the consistent moderate performance of Irish students in STEM-related subjects is at least partially responsible for not fulfilling this aspiration (DES, 2017e).

Chief Inspector's Report

Of particular importance to the area of high achievement has been the *Chief Inspector's 2018 report*, which identifies the strong focus on improved outcomes for all learners as a main objective in education in Ireland (DES, 2018). Among the stated short-term priorities is allowing all students to achieve their potential, with highest-achieving students being at the core of this objective. As noted in the "Looking Forward" chapter of the report: "…in order to challenge higher-performing students to achieve to their full potential, we need to focus on developing their cognitive skills to a greater extent by focusing on skills development as provided for in the primary and post-primary curricula" (DES, 2018, p. 97). This statement serves to underline that, despite best

intentions and explicit commitments being made in national policies, meeting the needs of high achievers remains a challenge.

2019–2021: Latest Results on International Large-Scale Assessments

The need for additional focus on high achievement in mathematics and science is further supported by Ireland's performance on the latest administrations of PISA and TIMSS (McKeown et al., 2019; Perkins & Clerkin, 2020). PISA 2018 and TIMSS 2019 data for Ireland provide further evidence corroborating the already existing patterns pertaining to high achievement in mathematics and science. Specifically, although Ireland had a statistically significantly higher average performance across all three PISA subjects compared to the OECD averages, percentages of high achievers in mathematics (8.2%) and science (5.8%) were statistically significantly lower and non-different from the OECD averages of 10.9% and 6.7%, respectively. Also, among the 10 countries with similar average mathematics performance to Ireland, nine had a statistically significantly higher and one had a similar percentage of high achievers to Ireland, while among the 11 countries with similar average science performance to Ireland, six had a statistically significantly higher and five had a similar percentage of high achievers to Ireland.

In TIMSS 2019, Irish fourth- and eighth-grade students' average scores in mathematics and science were statistically significantly higher compared to the TIMSS averages, as were the percentages of high achievers in both subjects and grades (Ireland – Grade 4: mathematics 15%, science 9%; Grade 8: mathematics 7%, science 10%; TIMSS international medians – Grade 4: mathematics 7%, science 6%; Grade 8: mathematics 5%, science 7%). When compared to countries with similar average performance, Ireland had mostly equal percentages of high achievers in the two subjects at Grade 4; however, at Grade 8, all and four out of eight comparison countries (i.e., countries with similar average performance to Ireland in each subject) had statistically significantly higher percentages of high achievers in mathematics and science, respectively. Given that one might expect similarly achieving countries to have similar distributions of students across the performance continuum, these patterns, which, though consistent for both subjects, were more pronounced in mathematics compared to science, indicate that Ireland continues to lag behind with regards to high achievement in mathematics and science, especially at post-primary level. This is also corroborated by the fact that only slight improvements (at primary level) or no improvements (at post-primary level) in the percentages of high-achieving students have been recorded across the administrations of PISA, TIMSS, and NAMER to date.

Discussion and Conclusions

Key Irish educational policy documentation pertaining to mathematics and science education and, particularly, high achievement in these two subjects since 1995 was

reviewed in this paper. Table 1 presents a summary of the main characteristics of each of the documents considered in this review.

Two main inferences were drawn from this review. First, results from national and international assessments exert significant and ever-increasing influence on educational policymaking in Ireland. Results from such assessments have frequently been used as performance indicators in an array of Irish educational policy documents. This has contributed to the formation of national targets for Irish students' performance in areas where weaknesses have been detected, including high achievement in mathematics and science.

Second, despite the policy attention and the numerous national targets that have been set in relation to high achievement in mathematics and science as a response to results from international large-scale assessments, there is a scarcity of relevant research-driven guidelines and practice reforms specifically tailored to better addressing the needs of high achievers, notwithstanding efforts by such organisations as the NCCA and the Professional Development Service for Teachers (PDST) to implement change in classrooms and schools in relation to mathematics and science education. Consequently, this review corroborates Walsh's (2016) argument based on a 100-year review of curriculum development and implementation in Ireland that, even though Ireland sets ambitious educational targets, what is absent from the majority of the policy documentation is the "roadmap required to move from the contemporary practice to the policy aspiration" (p. 12). A possible reason for this lack of focus on implementation in relation to high achievement may be that research evidence providing specific recommendations on how to accomplish such policy objectives has been scarce both nationally and internationally. Thus, recommendations for teaching and learning within the realm of high achievement could not be easily developed. Within this context, it is also important to acknowledge the potential mismatch between the system-level targets on the basis of Ireland's performance on large-scale assessments, such as the ones discussed in this paper, and the school-level targets that individual schools might use to gauge progress, given that some system-level targets might not be directly relevant to individual schools and students. While this might suggest a need for strategic leadership and guidance at the school level, in terms of gauging progress, not only on average, but in terms of high (and low) achievers, it also provides some insights into the potential reasons that system-level targets have not yet, for the most part, been met.

Much of the existing research literature on mathematics and science education to date has been populated by studies focused on low achievement in these two subjects. This emphasis on low achievement can be attributed to the fact that this group of students is more vulnerable to social exclusion, lower lifetime earnings, and higher unemployment rates compared to others (see Baker, 2015). Nevertheless, while it is important to address the needs of low-achieving students, the needs of high-

TABLE 1

Summary of Key Irish Policy Documentation on Mathematics and Science Education

Year	Name of policy, initiative or group	Main focus of policy, initiative or group	Focus on mathematics	Focus on science	Focus on high achievement
1995	Charting our Education Future: White Paper on Education	Comprehensive policy agenda for change informed by emerging trends in educational provision and practice across all levels of education			
1998	Education Act	Framework for providing for every individual, with specific emphasis on individuals with a disability or other special educational needs across all levels of education			
2005	Chief Inspector's Report 2001-2004	Report describing the work of the Inspectorate of the DES between January 2001 and December 2004	✓	✓	
2008	Project Maths	Project developed as a response to a series of identified difficulties in mathematics education in Irish post-primary schools, including Ireland's results in international large-scale assessments, involving the development of revised syllabi for both Junior and Leaving Certificate mathematics	✓		
2011	National Strategy to Improve Literacy and Numeracy	National strategy setting out a vision for raising standards across all levels of education, following concerning performance patterns in PISA 2009	✓		✓
2012	Higher Education Institutions' Bonus Points Scheme	Scheme for students taking Leaving Certificate mathematics at higher level – students achieving grades D3 or 6 and above in the old and new grading systems, respectively, are awarded 25 extra points	✓		
2013	STEM Education Review Group	Group responsible for a comprehensive review of STEM education in Irish schools	✓	✓	✓
2015	Education and Training Sector Overview of Service Delivery and Reform Report	Report identifying the priorities for the education and training sectors in Ireland			
2016	Action Plan for Education 2016-2019	Detailed annual action plans which contain actions set against quarterly delivery dates and reflect the Programme for Government's goals for education	✓	✓	✓
2016	Ireland's National Skills Strategy 2025	Initiative committed to assisting all individuals in reaching their full potential and contributing to the country's social, cultural, and economic development	✓	✓	
2017	Policy Statement on STEM Education 2017-2026	Set of proposals for STEM education in Ireland across three phases between 2017 and 2026	✓	✓	
2017	Interim Review Report of the 2011 National Strategy to Improve Literacy and Numeracy	Report of the interim review of the 2011 National Strategy to Improve Literacy and Numeracy, describing progress between 2011 and 2016, informed by consultation with stakeholders and evidence from national and international large-scale assessments	✓	✓	✓
2017	DEIS Plan	Set of objectives and actions to support children who attend disadvantaged (DEIS) primary and post-primary schools in Ireland	✓		✓
2018	Action Plan for Education 2018	Detailed annual action plan which contains actions set against quarterly delivery dates and reflect the Programme for Government's goals for education	✓	✓	✓
2018	Chief Inspector's Report 2018	Report summarising the key findings by inspectors through their inspections in schools, centres for education, and early years settings between January 2013 and July 2016	✓	✓	✓

achieving students should not be dealt with as a secondary issue but instead should be included in all educational agendas and appropriate actions should be taken towards this end. High achievement during schooling is associated with important benefits for individuals and societies that must not be disregarded. Hence, adopting balanced approaches whereby emphasis is given to addressing the needs of low-achieving students, without, at the same time, neglecting those of high-achieving students is expected to afford more students across the performance distribution the opportunity to achieve their potential. Such practices could help the Irish education system achieve greater levels of excellence, equity, and inclusiveness – something that countries like Australia, Canada, Estonia, Finland, or Japan have been able to achieve, as PISA data have shown (e.g., Schleicher, 2014).

Considering that policy and practice informed by research on low achievers have been linked to gains across several domains for this group of students (Griffin et al., 2012; Shiel et al., 2016), similar endeavours relating to high achievement are also likely to have promising outcomes for this group of students. As a first step towards this end, empirical studies specifically focused on high achievement (see, for example, Pitsia, 2021) are likely to be particularly useful. A comprehensive review of the 2011 *Literacy and Numeracy Strategy* (to also include Digital Literacy) is among the stated priorities for primary and post-primary education in the Programme for Government published in late 2020 (Department of the Taoiseach, 2020), which also includes a focus on raising achievement standards at the upper end of the performance distribution. In this context, such research is expected to be particularly valuable in informing relevant guidelines and recommendations specifically tailored to the needs of high achievers.

While new research focused specifically on high achievers is, indeed, warranted, the usefulness of resources for mathematics and science education that have already been developed by various Irish educational agencies, including those charged with supporting teachers to implement Project Maths, should be recognised and used complementarily with research findings. Most importantly, it is imperative that teachers and parents are made aware of this range of supplementary programmes available for teaching these two subjects and for supporting their children at home, respectively. This is important as solutions to educational issues may not only require newly developed resources but also awareness and appropriate use of existing ones. Bringing such resources together and organising them thematically, such as efforts being made by *sfi.ie*, *scoilnet.ie*, and *smartfutures.ie* as well as making them readily available for teachers, parents, and students is likely to assist towards this end. In this way, a "roadmap" that could bring relevant targets, such as the ones set across the relevant Irish educational policy documents discussed above, to fruition can be formulated.

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