

Primary & Secondary Education

The background paper has very little reference to STEM education in the primary and post-primary sectors. Without a firm foundation in their STEM education at both primary and post-primary there will not be third or further education students interested in seeking to continue their STEM studies.

There is a lot going on in the STEM area at present, particularly at post primary level for mathematics and the sciences, but review and revision is commencing in the primary sector.

The SSTI (2006 – 2013) outlined how we must build a strong science foundation in both primary and second level education. The SSTI called for a strengthening of the links between primary and post-primary. These will continue to guide work on the STEM agenda for primary and post-primary. In addition, the links between post-primary and third level education must also be strengthened so that there is a bridge and not a chasm between the two sectors.

There also must continue to be links nurtured between scientific institutions – both from the academic and business sectors – so as to motivate young people to realise the importance of STEM education for their futures and for the Irish economy. The work of SFI in this agenda is vital. Initiatives such as the annual Young Scientist and Technology exhibition and Scifest also play a key role in raising awareness of the STEM agenda and provide an opportunity for students to be creative, innovative and entrepreneurial. It also assists in promoting a positive attitude to careers in the STEM areas.

The Department of Education and Skills is currently overseeing a significant amount of curricular reform in the STEM area.

Due to the recent introduction of new Junior Cycle and Leaving Certificate specifications for Mathematics, colloquially known as “Project Maths”, and the provision of 25 bonus points for CAO applications to candidates who achieved a D grade in Higher Level Leaving Certificate mathematics, the number of candidates presenting for Higher level mathematics at LC has risen significantly. This has had a knock on effect also at Junior Certificate. Appendix 1 provides data on candidates presenting for LC and JC in 2006 – the start of the SSTI life and 2014 – the most recently available statistics

New specifications have been prepared for Leaving Certificate Biology, Chemistry and Physics. They include a new practical assessment component in the state examinations. The logistics relating to this have to be determined before the specifications can be implemented. In addition, a new Junior Cycle specification for Science will commence its implementation in schools from September 2015. In all of these specifications the development of skills, problem solving and inquiry based learning has been prioritised.

The NCCA is currently working on developing new specifications for Agricultural Science and Applied Mathematics. Work on other subjects, particularly the technology and Engineering suites, will be commenced on a phased basis into the future.

At primary level work has commenced on the development of primary mathematics firstly for the infant classes to second class. This will be followed by the development of mathematics for the primary senior classes.

All of the work of the Department, of the NCCA, of our STEM teachers and students in the primary and post-primary sectors is complemented through the work of Discover Science and Engineering awareness raising in particular through their training of teachers.

Primary Education

The Chief Inspectors report 2010-2012 has a sizeable section dealing with the quality of teaching and learning in mathematics. The findings are based on 778 WSE inspections with Mathematics as the primary focus and includes in total the findings from 1391 classroom visits. Inspectors reported that teaching approaches in mathematics lessons were satisfactory or better in 83% of lessons evaluated during incidental inspections and that learning outcomes for pupils were satisfactory or better in 85% of lessons.

The Inspectorate's Science in the Primary School Thematic Report (2008) contains much that is encouraging with regard to the teaching and learning of Science in Irish primary schools. The evidence indicates that a significant number of primary schools were experiencing success in many aspects of the science curriculum and that teachers and pupils were benefiting from the broad and balanced range of learning experiences outlined in the curriculum. Many schools were involved in projects and initiatives that support the objectives of the science curriculum. The report also outlines areas for improvement. In particular, inspectors found that schools needed to provide more regular opportunities for pupils to engage in problem solving and open-ended investigations and to develop the skills listed in the Working scientifically and Designing and making sections of the curriculum.

National assessments of English reading and mathematics at Second and Sixth classes (NA 2014) were conducted in May 2014 in a representative sample of 150 primary schools using secure tests. The findings were very encouraging. Overall performance on reading and mathematics in Second and Sixth classes was significantly higher in NA 2014 than in NA 2009. These are the first significant improvements in standards in reading and maths recorded by the national assessments in over thirty years. In addition, all of the targets in the National Literacy and Numeracy Strategy relating to attainment at primary level have been reached well in advance of the scheduled target date of 2020.

Post-primary education

The Chief Inspector's Report deals explicitly with the quality of teaching and learning in Mathematics (as well as Irish and English). It is of concern that the quality of Mathematics teaching was satisfactory or better in just 77% of the lessons observed in subject inspections in post-primary schools. Inspectors also found that student learning was less than satisfactory in more than one quarter (26%) of the lessons.

182 post-primary schools participated in PISA 2012 where Mathematics was the major domain and Science a minor domain. The performance relating to science was particularly encouraging with mathematics performance showing considerable improvement in PISA 2009 and a return to the level of performance in 2003 when Maths was again the major domain.

The introduction of Project Maths is one of the most positive developments in promoting STEM as an integral part of classroom activities as much of the material students encounter and the techniques they develop are embedded in the practical applications of Mathematics including Science and Technology. Outcomes from PISA 2012 indicate that the introduction of Project Maths has been positive in terms of student attainment particularly in relation to problem solving amongst girls.

Appendix 1 Leaving Certificate and Junior Certificate statistics.

Leaving Cert Maths

2014: 28% of candidates took the Higher Level Paper, while 62% took Ordinary Level and 10% took Foundation Level

2006: 18% of candidates took the Higher Level paper, while 71% took Ordinary Level and 11% took Foundation Level

Leaving Cert Physics

2014: 75% of candidates took the Higher Level paper, while 25% took Ordinary Level

2006: 71% of candidates took the Higher Level paper, while 29% took Ordinary Level

Leaving Cert Chemistry

2014: 84% of candidates took the Higher Level paper, while 16% took Ordinary Level

2006: 81% of candidates took the Higher Level paper, while 19% took Ordinary Level

Leaving Cert Biology

2014: 74% of candidates took the Higher Level paper, while 16% took Ordinary Level

2006: 69% of candidates took the Higher Level paper, while 31% took Ordinary Level

Junior Cert Maths

2014: 54% of candidates took the Higher Level paper, while 40% took Ordinary Level and 6% took Foundation Level

2006: 43% of candidates took the Higher Level paper, while 47% took Ordinary Level and 10% took Foundation Level

Junior Cert Science

2014: 78% of candidates took the Higher Level paper, while 22% took Ordinary Level

2006: 68% of candidates took the Higher Level paper, while 32% took Ordinary Level

Results of Irish students for Science in 2012

How well did Irish students perform on Science?

- Ireland's mean score in 2012 in science is significantly above the average score for OECD countries and shows a significant increase from 2006 (the last occasion when science was a major domain). Performance in science was also significantly higher than in 2009.
- Ireland is now ranked 9th among the 34 OECD countries and 15th of the 65 participating countries.
- In science, Ireland performed significantly below seven participating countries including Finland and Estonia. Ireland performed significantly above 45 countries including the US, Norway, Denmark and Sweden. Poland, Canada, Germany, Australia, New Zealand and the UK were among the twelve countries whose performance in science was similar to Ireland. Similar to maths and reading, students in Ireland significantly outperformed their counterparts in Northern Ireland. Appendix 5 provides more detail on the performance of Ireland relative to other countries.
- Encouragingly, Ireland achieved significantly higher scores than on average across OECD countries at both the 10th and 90th percentiles[1] i.e. both low-achieving and high-achieving Irish students scored better than the OECD average, and the performance of Irish students at both ends of the performance scale has shown significant improvement compared to 2006 and 2009.
- 11% of Irish students performed below Level 2 in science compared to an average of 17.8% across OECD countries, while the proportion of students performing at or above Level 5 is only slightly above the OECD average.
- There is no significant difference between the performance of Irish boys and girls in science with the scores of both being above their respective OECD averages and both showing significant improvement from 2006.
- Similar proportions boys and girls in Ireland score below Level 2 in science with a slightly higher proportion of boys scoring at or above Level 5.

What key conclusions can be drawn in relation to performance in science?

- Ireland's high overall performance and improved international ranking in science in 2012 is very welcome as there was no overall change from 2006 to 2009. It is very good too that the proportion of high-performing students has increased significantly since 2006 while the proportion of low-performing students has decreased considerably.
- The similarities in the scores for boys and girls in science contrasts with the stronger performance among boys in mathematics and girls in reading.
- There is scope for improvement in science, particularly among higher performing students. 10.8% students in Ireland performed at or above level 5 which is slightly higher than Northern Ireland and slightly below the UK. It is, however, well below that achieved in Shanghai-China (27%) and Finland (17%).
- While changes in the primary school curriculum (Department of Education and Science, 1999) and the junior cycle science syllabus (Department of Education and Science, 2003) may have contributed to the increase in science achievement observed in Ireland in 2012, the performance in science points to the need for on-going curricular reform and implementation in this area at primary and post-primary.

Results of Irish students for mathematics in 2012

How well did Irish students perform in Print Mathematics?

- For the first time in PISA, Irish students performed significantly above the OECD average on print mathematics. Ireland was placed 13th of the 34 OECD countries and 20th overall of the 65 countries.
- The score achieved by the lowest performing students (students at the 10th percentile) on overall mathematics in Ireland was higher than the corresponding OECD average.
- The score achieved by the highest performing students on overall paper mathematics (those at the 90th percentile) in Ireland was not significantly different from the average across the OECD and represented a slight drop in performance of this group of Irish students compared to 2003. Given that overall mathematics performance is above the OECD average, this suggests that higher achieving students in Ireland are underachieving.
- The average proportion of students across OECD countries who perform below Level 2[2] on overall print mathematics is 23.1%. Encouragingly, the proportion of Irish students (16.9%) that perform below Level 2 on print mathematics is well below this.
- 11% of Irish students performed at the highest levels of proficiency (at or above Level 5). This is slightly below the OECD average of 13%.
- Irish boys outperformed girls in print mathematics both overall and across each of the content and process areas[3]. Gender differences in performance in Ireland in PISA 2012 showed little or no change from 2003. The proportion of boys and girls scoring below Level 2 and at or above Level 5 also showed little change from 2003. The difference between the performance of boys and girls is slightly higher in Ireland compared with the average differences across OECD countries but not significantly so.

How well did Irish students perform in Computer-based Mathematics?

- Compared to their performance on the print mathematics assessment, Irish students did significantly less well on the computer-based assessment of mathematics. However, it is difficult to draw satisfactory conclusions from the outcomes of this element of the assessment as there were wide differences in the performance of many countries across the two modes of assessment. Of the 32 countries participating in both the print- and computer-based mathematics assessments, 15 scored better on the print mathematics assessment while 17 performed better on the computer-based assessment. The average score for Irish students on the computer-based assessment of mathematics was not significantly different from the corresponding OECD average score.
- Lower-achieving students in Ireland (those scoring at the 10th percentile) performed slightly, but not significantly, above the OECD average on computer based mathematics while our higher-achieving students (those scoring at the 90th percentile) performed significantly below the OECD average.
- Only 7% of Irish students scored at Level 5 or above on computer-based mathematics, compared with 11% on average across OECD countries.
- As with print mathematics, boys outperformed girls on the computer-based assessment. Irish boys performed, on average, at the same level as boys did on average across OECD countries, while girls performed significantly less well. The gap in performance between Irish

boys and girls is greater for computer-based mathematics than for print mathematics, with twice as many boys as girls scoring at Level 5 or above on the latter.

PISA 2012 Computer Based Assessment of Problem Solving

In PISA 2012, problem solving was included as an optional assessment. Of the 65 countries that participated in the 2012 PISA assessments, 44 countries/economies, including Ireland and 27 other OECD countries, participated in a 40-minute computer-based assessment of problem-solving. In Ireland, 1,303 15 year old students in 183 schools participated in the computer-based assessment of problem solving. The results of this assessment were published in April 2014 after the publication of the results of the main study.

PISA 2012 is the second cycle of PISA that has included individual problem solving as an additional assessment domain. The assessment of problem solving was last included in 2003 but has been significantly revised since then. Most notably, the assessment in 2012 moved to a computer-based platform that allows for the inclusion of interactive problems (i.e. where students can explore the situation to uncover additional relevant information). Examples of interactive problem situation include encountering technological devices (e.g., mobile phones or ticket vending machines) for the first time. The 2003 assessment of problem solving included static problems only (i.e. where all the information is disclosed at the outset and the problem situation is not dynamic).

Also while PISA 2003 tested cross-disciplinary problem-solving, PISA 2012 expressly excluded problems requiring expert knowledge of particular curricular areas for their solution.

The performance of Irish students on problem solving was good but there was considerable scope for development. The following are some of the positive features of Ireland's performance:

- Students in Ireland performed at the OECD average on problem solving in PISA 2012. Ireland is ranked 17th of 28 participating OECD countries and 22 of all 44 participating countries/economies.
- The performance of lowest-performing students and highest-performing students on problem solving is similar to the OECD average for such students.
- The proportion of students in Ireland performing below the baseline level of proficiency (i.e. below Level 2) is similar to the OECD country average.
- There is no significant difference between the performance of male and female students in Ireland. The performance on problem solving of both male and female students in Ireland is similar to the corresponding OECD averages.
- The mean score of students in Ireland with an immigrant background is significantly higher than the corresponding average for the OECD although significantly lower than that for native students in Ireland.
- Performance on interactive problem solving assessment items is stronger in Ireland than expected, given the relative difficulty of these items compared with the static items

Report on Project Maths and PISA 2012: Performance in Initial Project Maths Schools and Non-initial Schools on PISA 2012 Mathematics and Problem-solving and on Junior Certificate Mathematics

The Educational Research Centre (ERC) published a report on the initial impact of Project Maths as a curriculum reform intervention using PISA 2012 as an assessment tool. The purpose of this analysis was to compare the performance of students in the 23 Initial Project Maths schools (the first cohort

of schools to roll out Project Maths) with those in the Non-initial schools using data from PISA assessments.

There is evidence that Project Maths is having an initial positive impact on student achievement in Maths.

- 15-year olds in the 23 schools in which Project Maths was implemented initially achieved an expected score on PISA maths that was 10 points higher than the score of students in Non-initial schools.
- Students in the Initial schools achieved an expected score that was one-third of a grade point higher than the corresponding score of students in Non-initial schools in the Junior Certificate examination.
- There was also evidence of stronger performance on PISA Space and Shape, with girls in Initial schools showing most improvement. Shape and space is one of the areas of mathematics where Irish students have performed poorly in the past and one of the key aims of Project Maths was to address this issue