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Science, Technology, Engineering and Mathematics (STEM) in 2015

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This research paper is prepared for the Committee for Education to support its consideration of science, technology, engineering and maths (STEM). It considers progress against a number of areas highlighted in the 2011 *Success through STEM* Strategy in 2011.

Executive Summary

Introduction and background

This research paper is prepared for the Committee for Education to support its consideration of science, technology, engineering and maths (STEM). It considers progress in Northern Ireland against a number of areas highlighted in the 2011 *Success through STEM* Strategy in 2011.

The Review aimed to address a number of issues, including a decline in interest in STEM and a lack of confidence among many primary teachers in relation to teaching science. Its recommendations for the Department of Education (DE) included:

- Ensuring a strong focus on professional development and raising the number of applications for places on STEM Initial Teacher Education (ITE) courses;

- Introducing new end of key stage assessments in maths;

- Making STEM more enquiry based and developing new STEM resources; and,

- Increasing attainment in STEM from Key Stage 1 to GCSE.

Uptake of STEM subjects

There was an overall increase in the uptake of STEM GCSEs between 2004/05 and 2012/13, rising from 33.9% to 37.7% of all exam entries. However, the proportion of GCSE exam entries that were in STEM subjects decreased by 1.9% in 2013/14.

The evidence also indicates a trend for greater proportions of students studying individual STEM GCSEs, with a reduction in the percentage studying both Single and Double Award Science.

At A level, there has been a gradual increase in the proportion of exams taken in STEM since 2004/05, rising from 37% of all entries to 41.1% in 2013/14. However, over the same period there has been an overall decrease in the proportion of students with an A level entry in one or more STEM exams from 48% to 45%. Further information is required to understand the reasons for this disparity.

The DE's Corporate Plan 2012-15 included a goal to increase the proportion of STEM exam entries at post-16. The milestone for 2014/15 was to deliver a 5% increase in the percentage of sixth form pupils studying STEM by 2014/15. However, by 2013/14 there was a decline of 3.1% in the proportion of students with one or more exam entries in STEM since 2011/12.

At both GCSE and A level, males were more than females likely to study STEM. However, trends in uptake for both genders are broadly similar over the past ten years.

Performance in STEM

Research published in 2011 suggests that Northern Ireland's performance in primary maths is among the best in the world, although a number of countries significantly outperformed it in science.

However, in a 2012 post-primary study, Northern Ireland's students performed significantly less well than the Organisation for Economic Cooperation and Development (OECD) average in maths, and it had a relatively low proportion of students achieving at the highest levels.

In science, Northern Ireland's results were in line with the OECD average. While it had a greater proportion of high achievers than the international average, it also had a higher percentage of students with low scores than other high achieving countries.

ITE and Continuing Professional Development (CPD)

The evidence indicates that a lower proportion of primary pupils in Northern Ireland are taught by teachers with a specialism in science or maths in comparison to other countries. The data show that there has been an overall decrease in enrolment on ITE physics and chemistry courses since 2011/12.

A wide range of STEM CPD initiatives, programmes and events are available to schools. However, in a recent survey, just over a third (37%) of primary teachers had taken part in STEM training and 24% called for further CPD in this area. In addition, the DE cut funding for a number of CPD initiatives in 2015/16.

Primary science teaching and enquiry based learning

A recent evaluation of *'The World Around Us'* found that the science and technology elements were underdeveloped in just over half (54%) of primary schools inspected. Schools highlighted a number of challenges in this regard, including a lack of access to training, competing priorities and the current focus on assessment. Other issues identified by the literature include that:

- There is a lack of confidence among many teachers around teaching science;

- Northern Ireland spends less time teaching primary science than on average internationally; and,

- In Northern Ireland, 13% of pupils' teachers emphasised science investigation in half of lessons or more, in comparison to an international average of 40%.

Careers advice and guidance

The literature highlights concerns among many stakeholders regarding the quality of careers advice in schools, suggesting that effective advice and guidance on potential careers, particularly for girls, is crucial in promoting STEM. In 2013 the Committee for

Employment and Learning recommended that the DE include more career insights and exposure to business in its STEM careers provision.

STEM in other jurisdictions

Efforts to promote STEM are underway in a range of countries, with many focusing on teacher recruitment and development.

For example, the Department for Education in England offers teacher training scholarships to top graduates in key subject areas, including STEM. These will be worth up to £30,000 for graduates with a first class honours or PhD in physics in 2016/17. In the Republic of Ireland a two year part-time Professional Diploma in Mathematics for Teaching aims to support teachers without a maths specialism.

Conclusion

This paper has highlighted a number of issues around the teaching of science in primary schools, and noted a number of areas that could be given further consideration in regard to progress through the *Success through STEM* strategy.

Further consideration could be given to:

- The evidence that many primary teachers do not feel equipped to teach STEM;

- The lower teaching time for primary science in Northern Ireland compared to other countries internationally;

- The low proportion of primary teachers emphasising science investigation in their lessons;

- The low proportion of primary pupils availing of the STEM Module;

- The reasons for the disparate findings at A level in terms of the increasing proportion of exam entries in STEM subjects, while there is a decline in the proportion of students entering one or more STEM exam;

- The decline in the proportion of A level students taking one or more STEM exams in light of the DE Corporate Plan goal to increase the proportion by 5%;

- The decline in pupil performance in maths from primary to post-primary education and the proportion of post-primary students achieving low maths scores in PISA;

- The higher proportion of male students studying STEM;

- Concerns around inadequate access to CPD in STEM and recent funding cuts;

- The decreasing number of enrolments in STEM courses in ITE;

- Concerns around STEM careers advice and guidance in schools; and,

- Practice in other jurisdictions, such as bursaries aiming to attract high performing STEM graduates to teaching.

Contents

Introduction

This research paper is prepared for the Committee for Education to support its consideration of science, technology, engineering and mathematics (STEM).

The paper initially provides background information to contextualise a discussion about a number of areas highlighted in the *Success through STEM* strategy, published by the Department of Education (DE) and the Department of Employment and Learning (DEL) in 2011. The findings are extracted from a range of available sources, as well as information provided to RaISe by the Department of Education.

These areas include: the uptake of STEM in Northern Ireland; Northern Ireland's performance in these subjects in an international context; the development of teachers; primary teaching and enquiry based learning; and, coding in primary schools. It also provides an overview of actions taken to promote STEM in other jurisdictions. The paper concludes highlighting key observations and scrutiny points.

1   Background

The DE and the DEL commissioned a review of STEM in Northern Ireland and published the final report in September 2009. The review found that:[1]

- There is a decline in interest in STEM among primary school children;

- Many primary teachers lack the confidence and knowledge to teach science; and,

- There is a decline in the uptake of maths, physics and computing at A level.

In 2011 the DE and the DEL published *Success through STEM*, a strategy for STEM following on from the joint 2009 review. The strategy set out a series of recommendations for the DE, including to:[2]

- **Address the disparity in STEM performance** between schools, including by ensuring a strong focus on professional development;

- **Support primary teachers in teaching The World Around Us**, including through the development of new resources;

- **Review ongoing developments in maths** in relation to STEM provision, including the introduction of new end of key stage assessments;

- **Make STEM learning more enquiry based**, including through use of the STEM Truck and the design of new resources;

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[1] Department of Education and the Department of Employment and Learning (2009) *Report of the STEM Review* Belfast: DE and DEL

[2] Department for Employment and Learning and Department of Education (2011) *Success through STEM: STEM Strategy*

- **Increase the focus on core sciences and maths**, including by focusing on attainment in maths from key stage 1 to GCSE; and,

- **Increase the number of applications for physical sciences and mathematics places** in Initial Teacher Education Courses.

2 Uptake of STEM subjects

Success through STEM: One Year On, published in 2012 by the DE and the DEL, noted that the DE had been making *"strenuous efforts"* to encourage the uptake of STEM subjects in Northern Ireland, but that more needed to be done.[3] Those areas identified for improvement are discussed in the following paragraphs.

2.1 GCSE

Over a ten year period from 2004/05, data provided by the DE indicates that there has been an overall increase in the uptake of STEM at GCSE. In 2004/05 just over a third (33.9%) of all exam entries were in STEM subjects, rising to 37.7% in 2013/14. However, the latest year for which data was available (2013/14) saw a decrease of 1.9% in STEM exam entries, as illustrated by Figure 1 below.[4]

Male students represented a greater proportion of exam entries than their female counterparts. However, the trends in uptake over time were similar for both male and female students, as highlighted by Figure 1.[5]

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[3] Department of Education and the Department of Employment and Learning (2012) *Success through STEM: One Year On* Belfast: DE and DEL

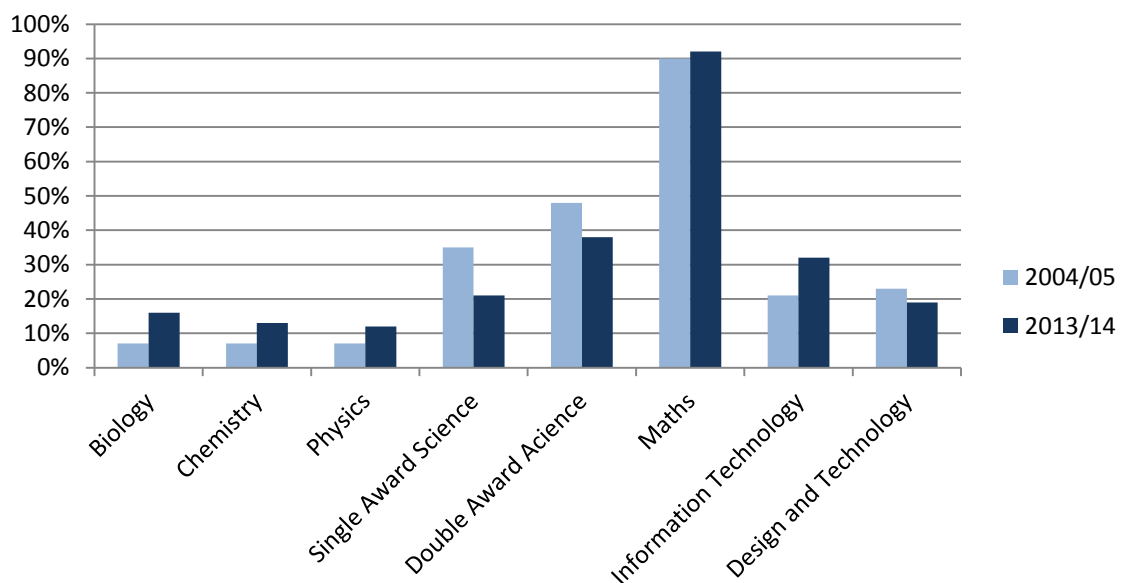[4] Data provided by the Department of Education, October 2015

[5] Data provided by the Department of Education, October 2015

Figure 1: Proportion of all GCSE exam entries that were in STEM subjects from 2004/05 to 2013/14[6]
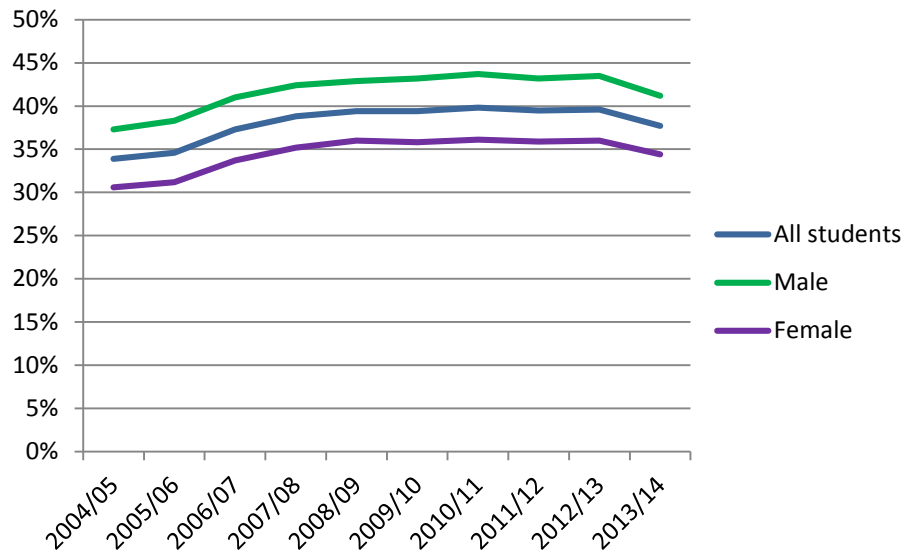
An analysis of the uptake of individual STEM subjects also highlights a number of trends. Figure 2 below shows that between 2004/05 and 2013/14, there has been a reduction in the number of students taking Single and Double Award science. For that same time period, the proportion of students taking biology, chemistry and physics individually has increased.

Figure 2: Proportion of students with a GCSE entry in individual STEM subjects in 2004/05 and 2013/14[7]

2.2   A level

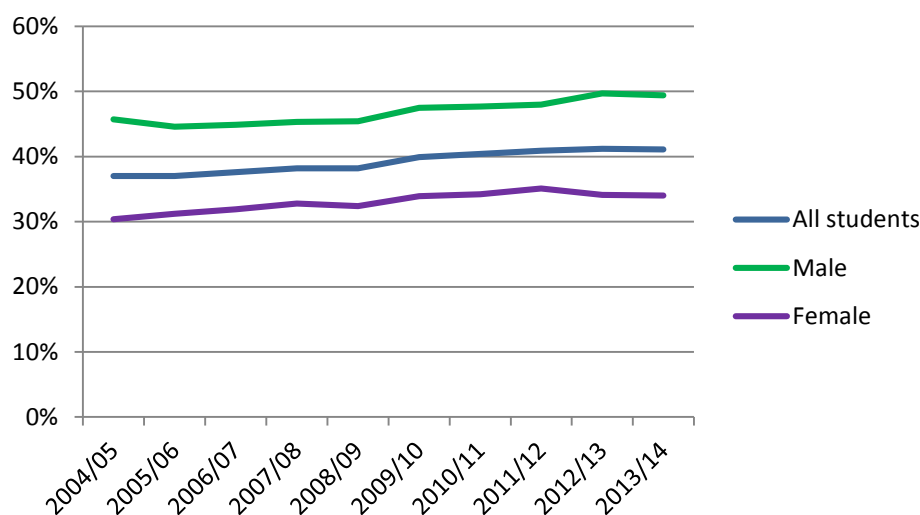[6] Data provided by the Department of Education, October 2015

[7] Data provided by the Department of Education, October 2015

Data provided by the DE evidences a gradual increase in the proportion of exam entries in STEM subjects over the past ten years. There was an increase from 37% of all A level entries in STEM subjects in 2004/05 to 41.1% in 2013/14.[8]

The DE's *Business Plan 2015/16* includes an indicator aiming to increase the proportion of A level STEM exam entries, from a baseline of 40.9% in 2011/12.[9] Using the most current data available, in 2013/14 the proportion of entries had increased to 41.1%.[10]

Figure 3 overleaf shows the proportion of A level entries in STEM subjects between 2004/05 and 2013/14. It highlights a gradual increase in the proportion of exams taken in STEM subjects over the ten year period. In line with findings at GCSE, male students were more likely to study STEM subjects than females. Trends in uptake over time for male and female students were again broadly similar.[11]

Figure 3: Proportion of all A level exam entries that were in STEM subjects from 2004/05 to 2013/14[12]

However, considering the proportion of students with an entry in one or more STEM subjects, rather than the proportion of exam entries in STEM subjects, there was an overall decrease in the percentage of A level students entering one or more STEM exam(s), from 48% in 2004/05 to 45% in 2013/14.[13] This is illustrated by Figure 4 below.

Further information is required to understand the reasons behind this disparity, such as the number of exams taken by individual students and whether other qualifications are no longer available.

[8] Data provided by the Department of Education, October 2015

[9] Department of Education (2015) *Department of Education 2015/16 Business Plan* Bangor: DE

[10] Data provided by the Department of Education, October 2015

[11] Data provided by the Department of Education, October 2015

[12] Data provided by the Department of Education, October 2015

[13] Data provided by the Department of Education, October 2015

Figure 4: Year 14 pupils with one or more STEM A level entry
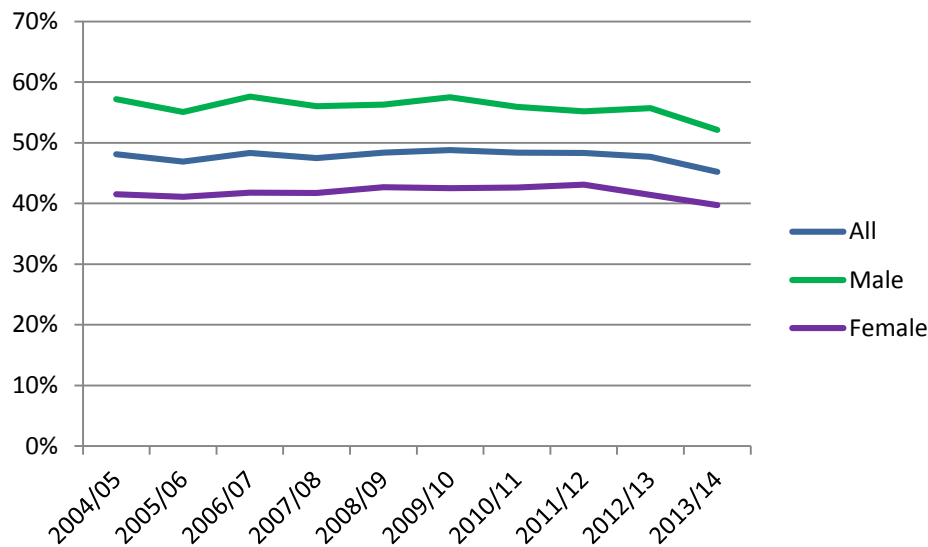
The DE's *Corporate Plan 2012-15* included a key success indicator to increase the proportion of STEM examination entries at post-16. The 2014/15 milestone for this indicator was to deliver a 5% increase in the percentage of sixth form pupils studying STEM subjects by 2014/15.[14]

While data is not yet available for the 2014/15 academic year, the data for 2013/14 show a decline of 3.1% in the proportion of Year 14 pupils with one or more exam entry in any STEM subject since 2011/12.[15] In addition, Figures 3 and 4 above suggest that the indicator and its associate milestone are inconsistent, as they produce diverse results.

Figure 5 below highlights an overall decline in the uptake of a number of A level STEM subjects; although there has been an increase in students taking maths and Information Technology.

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[14] Department of Education (Review of Corporate Plan for Education 2012-2015) Bangor: DE

[15] Data provided by the Department of Education, October 2015

Figure 5: Year 14 pupils with an A level entry in individual STEM subjects in 2004/05 and 2013/14[16]
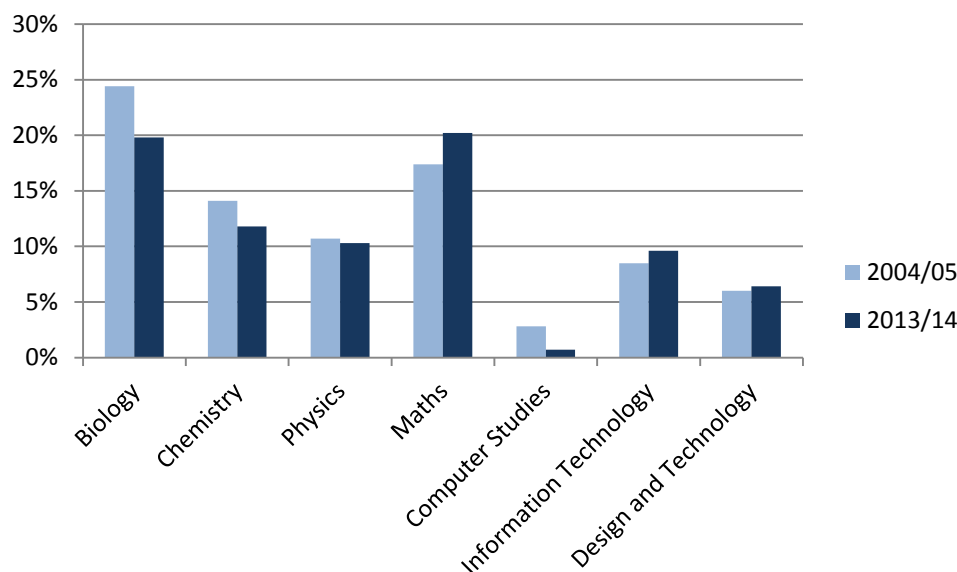
3   Primary performance in STEM

This section considers Northern Ireland's performance in STEM subjects at primary school level.

3.1   End of key stage assessments

Success through STEM recommended that the DE introduce new end of key stage assessments with a focus on maths and using ICT.[17] In 2012 the DE introduced new assessment arrangements using Levels of Progression.[18] However, a 2013 survey by the General Teaching Council for Northern Ireland found that less than 12% of teacher respondents believed the assessments to be *"reliable"* or *"very reliable"* across the education system.[19] In addition, Using ICT has been deferred in light of schools' concerns around their readiness for assessing this skill.[20]

The DE issued a position paper in 2014 in response to the concerns of teachers and trade unions, noting changes they had made to assessments.[21] Nonetheless, CCEA

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[16] Data provided by the Department of Education, October 2015

[17] Department for Employment and Learning and Department of Education (2011) *Success through STEM: STEM Strategy*

[18] Department of Education and the Department of Employment and Learning (2012) *Success through STEM: One Year On* Belfast: DE and DEL

[19] General Teaching Council for Northern Ireland (2013) *Issue 1: Your Views on Statutory Assessment* Belfast: GTCNI

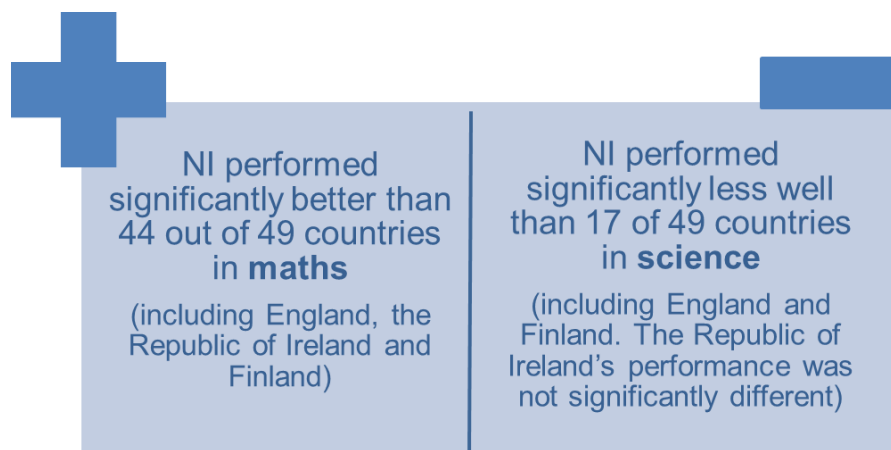[20] Minister for Education (2014) *End of Key Stage Arrangements: Moving Forward in 2014/15: Letter to Schools*

[21] Department of Education (2014) *Position paper to clarify changes for schools* [online] Available at: https://www.deni.gov.uk/sites/default/files/publications/de/departmental-position-paper-statutory-end-of-key-stage-assessment-october-2014-english-version.pdf

reports that uptake of the assessments has been limited, undermining analysis of the results.[22]

3.2   International comparison

The Trends in International Maths and Science Study (TIMSS) allows for comparisons between Northern Ireland and other jurisdictions in primary maths and science. Figure 6 below shows that Northern Ireland's students performed among the best in the world in maths, but had lower results for science.[23]

Figure 6: Northern Ireland's performance in primary maths and science in 2011[24]

NI performed significantly better than 44 out of 49 countries in **maths**

(including England, the Republic of Ireland and Finland)

NI performed significantly less well than 17 of 49 countries in **science**

(including England and Finland. The Republic of Ireland's performance was not significantly different)

TIMSS found that there was no significant difference between the performance of boys and girls in science in Northern Ireland. This is in line with findings for 22 other countries, including England and the Republic of Ireland.[25]

4   Post-primary performance in STEM

The Programme for International Student Assessment (PISA) provides international comparisons on the performance of students aged 15. Table 1 below shows that at post-primary, Northern Ireland's performance in maths was significantly below the Organisation for Economic Cooperation and Development (OECD) average. Its performance in science was in line with the OECD average.

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[22] Council for the Curriculum, Examinations and Assessment (2015) *CCEA Annual Report 2014/15* Belfast: CCEA

[23] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMMS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

[24] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMMS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

[25] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMMS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

Table 1: Northern Ireland's performance in post-primary maths and science in 2012[26]

	Maths	Science
International performance	• **Significantly below** the OECD average • 25 countries performed significantly better	• **Not significantly different** to the OECD average • 17 countries performed significantly better
Difference between high and low achieving pupils	• Relatively low proportion of pupils achieving the highest levels • **Similar spread of attainment** to the OECD average	• Higher proportion of high achievers than the OECD average • Greater proportion of lower attainers than other high achieving countries

5 Initial Teacher Education and professional development

5.1 Initial Teacher Education

Around three-quarters of pupils in Northern Ireland participating in TIMSS were taught by teachers whose main area of study had been primary education without a maths or science specialism. This compares to an international average of 46% of pupils in maths and 48% in science.[27]

Moreover, a tenth (10%) of pupils in maths and 11% in science were taught by teachers with a major in primary education and a specialism in maths or science. This was in comparison to TIMSS international averages of 28% and 25% respectively.[28]

The 2011 *Success through STEM* Strategy recommended an increase in the number of applications for physical sciences and mathematics places in Initial Teacher Education (ITE) courses, stating that the DE would ensure that STEM-related ITE places would reflect the needs of schools.[29]

However, the DE advised that while the Minister for Education determines the overall number of ITE places, these are not allocated by subject and it is up to the Higher Education Institutions to decide the numbers of available places for individual courses.[30]

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[26] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMMS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

[27] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMMS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

[28] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMMS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

[29] Department for Employment and Learning and Department of Education (2011) *Success through STEM: STEM Strategy*

[30] Information provided by the Department of Education, October 2015

Figure 7 below illustrates the total number of enrolments on physics and chemistry ITE courses. It shows that there has been an overall decrease in enrolment in these courses since the implementation of *Success through STEM*.

Figure 7: Enrolments on ITE courses in the physical sciences (physics and chemistry) and maths[31]
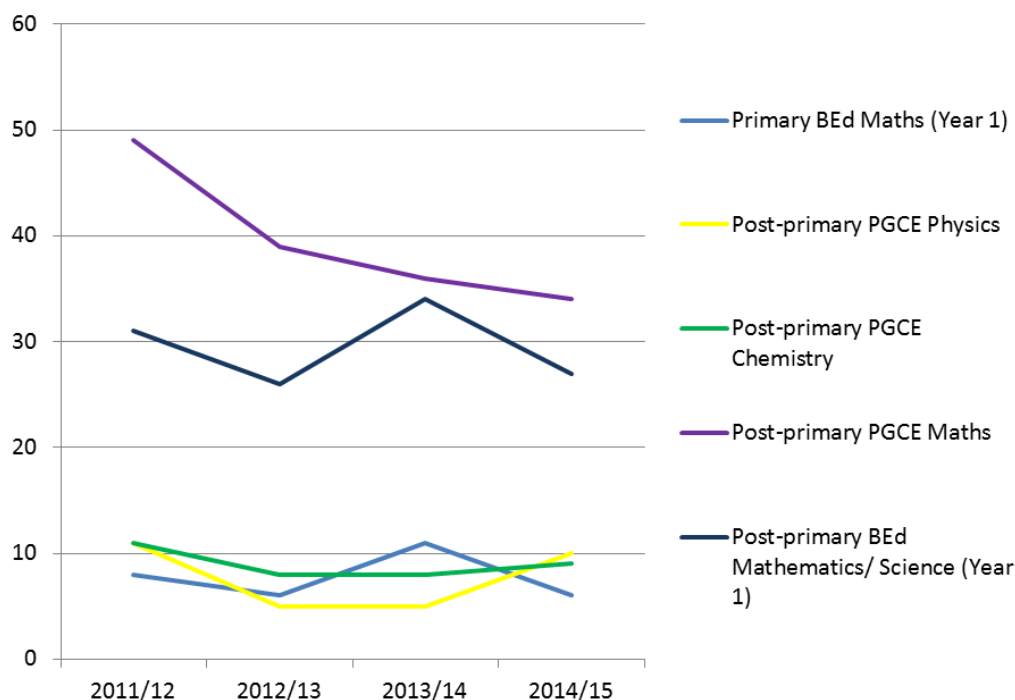
5.2 Continuing Professional Development

A further recommendation from *Success through STEM* was the development of a STEM Continuing Professional Development (CPD) framework, including the provision of professional development opportunities for teachers and opportunities for engagement with industry representatives.[32]

In October 2015, the DE advised that 3,502 teachers have attended STEM CPD initiatives for GCSE and A level since 2011/12. It noted a range of CPD opportunities available to teachers, including:[33]

- Council for Curriculum, Examination and Assessment (CCEA) training and events, such as events in conjunction with Allstate to support teachers in delivering A level Software Systems Development;

- Education Authority (EA) sessions facilitating engagement between teachers and industry representatives;

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[31] Data provided by the Department of Education, October 2015

[32] Department for Employment and Learning and Department of Education (2011) *Success through STEM: STEM Strategy*

[33] Information provided by the Department of Education, October 2015

- Queen's University Belfast and the University of Ulster training on A Level Software Development; and,

- EA Belfast Region contract with the National Science Learning Centre for CPD.

In addition, the EA's STEM Primary Project has provided training to 302 schools over a period of six years from 2009/10. However, there is variation by region, with 36% of schools trained in the Southern and North Eastern Regions, compared to 69% in the Belfast Region.[34]

5.2.1 Teacher views

The Education and Training Inspectorate (ETI) evaluation of the implementation of *'The World Around Us'* curriculum area found that 37% of schools responding to a survey had staff who had completed STEM training.[35]

In addition, almost a quarter (24%) of schools evaluated by ETI emphasised the need for further professional development from, for example, the Curriculum Advisory and Support Services (CASS). Teachers reported a need for training, particularly around planning and evaluating *'The World Around Us',* and asked for more opportunities to work with other schools.[36]

5.2.2 CPD funding cuts

In 2015/16 the DE reduced funding for a number of CPD initiatives, with an overall reduction in funding of £743,000. The cuts included:[37]

- STEM Careers Education, information, advice and guidance: reduced by £316,000;

- STEM Teachers' CPD: reduced by £214,000; and,

- Careers CPD project: reduced by £97,000.

The DE also cut all funding for the Smart Technology Programme run by Sentinus in 2015/16 (worth £84,392 in 2014/15).[38] This Programme aimed to support the development of teachers' skills in STEM, including those of teachers without a science specialism, and highlighting the importance of STEM within the *'World Around Us.'*[39]

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[34] Data provided by the Department of Education, October 2015

[35] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

[36] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

[37] Minister for Education response to an Assembly Question by Peter Weir MLA, 15th June 2015

[38] Information provided by the Department of Education, October 2015

[39] Department of Education and the Department of Employment and Learning (2012) *Success through STEM: One Year On* Belfast: DE and DEL

6   Primary science teaching and enquiry based learning

One of the recommendations from the DE/ DEL STEM Strategy was to make STEM resources more enquiry based. Indeed, evidence from TIMSS and the ETI evaluation of *'The World Around Us'* suggest that teaching and learning are less effective where there is a lack of genuine enquiry.[40]

6.1   Implementation of the science curriculum

The ETI evaluated implementation of *'The World Around Us'* curriculum area[41] in primary schools in 2014. ETI found that most (86%) of the science and technology teaching and learning evaluated was good or better.[42]

However, ETI noted that in just over half (54%) of primary schools inspected, the science and technology strand was underdeveloped. In such schools the provision had a narrow focus, lacking investigative experiences, and the teachers were less familiar with scientific skills and concepts.[43]

Indeed, ETI reported that just over half (54%) of the teacher survey respondents believed that they had included the progression of the relevant practical and experiential science and technology skills within their planning. They cited a number of reasons for this, including competing priorities (such as literacy and numeracy), the current focus on assessment and a lack of access to training.[44]

6.2   Teacher knowledge and skills

ETI also found that a third of schools surveyed disagreed or did not know if their staff had sufficient knowledge and skills to teach the science and technology elements of *'The World Around Us'*. This was in contrast to the other strands, with 94% agreeing that staff were equipped to teach history and 95% noting that they had the skills to teach geography.[45]

ETI's findings are supported by evidence from TIMSS, which found that while 91% of teachers felt very well prepared to teach maths, only 54% felt very well prepared to teach science. This was below the international average of 62% for science.

6.3   Teaching time

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[40] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

[41] This curriculum area combines geography, history, science and technology.

[42] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

[43] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

[44] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

[45] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

Evidence from TIMSS suggests that in Northern Ireland, total teaching time in primary schools was higher than the international average. In terms of individual subjects, teaching time was higher than average for maths, but lower than average in science. The highest performing countries in TIMSS science had greater teaching time in science.[46]

In the ETI evaluation, some principals and teachers raised concerns around the lack of statutory duty to teach science overtly. They suggested that science may be diluted and that practical or investigative aspects may be limited or not take place at all.[47]

6.4 Emphasis on science investigation

Evidence from TIMSS suggests that 13% of Year 6 pupils in NI were taught by teachers who emphasised science investigation in about 'half the lessons or more', in comparison to an international average of 40%. TIMSS further found that in England 41%, and in the Republic of Ireland 43%, were taught by teachers emphasising investigation in half of lessons or more.[48]

Internationally, TIMSS reported that pupils whose teachers emphasised science investigation in *'about half of lessons or more'* on average had higher performance than those whose teachers who focused on it to a lesser degree. However in Northern Ireland, it found no clear pattern between the focus on science investigation and pupils' average achievement.[49]

6.5 Collaboration between schools

The DE's School Omnibus Survey 2014 indicates that a much higher proportion of post-primary schools are working on the STEM agenda in collaboration with a primary school or Further Education (FE) college, compared to the number of their primary counterparts working with a post-primary or FE college (60% compared to 19%).[50]

6.6 Resources

Most primary schools visited during the ETI inspection believed that they had appropriate resources for *'The World Around Us'*. However, teachers had concerns around access to resources for practical learning.[51]

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[46] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMSS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

[47] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

[48] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMSS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

[49] Sturman, L., Twist, L., Burge, B. et al. (2012) *PIRLS and TIMSS 2011 in Northern Ireland: Reading, Mathematics and Science* Slough: NFER

[50] Department of Education (2014) *School Omnibus Survey - findings* 2014 Bangor: DE

[51] Education and Training Inspectorate (2014) *An evaluation of the implementation of The World Around Us in primary schools* Bangor: ETI

DE's *Success through STEM, One Year On* stated that Sentinus is the main STEM frontline service provider for schools. The report notes that Sentinus programmes play a "key role" in delivering DE's commitments.[52]

However, in 2015/16 funding for Sentinus was reduced from £659,851 the previous year to £300,000. This included the loss of two programmes: *"IT's Your Choice"* and the Smart Technology Programme (see subsection 5.2 of this paper).[53]

The STEM Module (STEM Truck), a mobile laboratory and workshop, is one of the ways in which the DE aims to support enquiry-based learning. Since April 2009 the total number of pupils who have availed of the STEM Module, and an estimation of the proportion relevant to the population based on 2014/15 data, are:

- At primary, 4,960 pupils or 3% of the total school population in 2014/15; and,

- At post-primary, 33,825 or 24% of the total school population in 2014/15.

7   Careers advice and guidance

CBI Northern Ireland has suggested that careers provision for most young people is poor, highlighting variation in quality across careers advisers who often lack industry experience. It emphasises the importance of informing pupils, particularly girls, about the potential range of STEM careers open to them, noting that quality careers advice with employer involvement is crucial in promoting STEM.[54]

In 2013 the Northern Ireland Assembly's Committee for Employment and Learning published a report of its inquiry into Careers Education, Information, Advice and Guidance. It set out a number of recommendations in relation to STEM, including:[55]

- The DE should consider expanding its approach to STEM careers advice to provide more career insights and exposure to business and entrepreneurship;

- The DE and the DEL must develop outcome measures to enable the Assembly and the wider public to evaluate success in promoting work-relevant areas, particularly STEM; and,

- The DE and the DEL should develop a strategy setting out how they will increase the number of female students entering STEM based careers.

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[52] Department of Education and the Department of Employment and Learning (2012) *Success through STEM: One Year On* Belfast: DE and DEL

[53] Information provided by the Department of Education, October 2015

[54] CBI Northern Ireland (2014) *Step Change: A new approach for schools in Northern Ireland* CBI

[55] Committee for Employment and Learning (2013) In*quiry into Careers Education, Information, Advice and Guidance in Northern Ireland* Belfast: The Stationery Office

8   Coding in primary schools

Coding is the process of developing sets of instructions (computer programmes) that allow computers to carry out tasks.[56] Recently there has been criticism of the emphasis on teaching ICT, which relates to *using* software in schools. It has been suggested that the focus should instead be on computer science, which has been described as a 'rigorous academic discipline,' incorporating coding.[57]

8.1   Formal and informal teaching

The Revised Curriculum does not directly refer to coding. However ICT is included as a cross-curricular skill, and there is some flexibility for schools to teach coding if they wish. There is limited evidence on the extent to which this happens in practice; although it has been suggested that coding is rarely taught in primary schools or prior to GCSE.[58]

In terms of informal teaching, a number of coding clubs and societies operate at lunchtimes, after school and during the holidays, and as such, may have limited numbers of pupils.[59]

8.2   CPD and coding initiatives

The DE and the Department of Enterprise, Trade and Investment provided £46,500 to Queen's University Belfast to pilot a course aiming to upskill post-primary teachers in delivering software systems development at A level in 2014/15.[60]

In 2014/15 the DE supported two Sentinus programmes incorporating coding, Smart Technology and *"IT's Your Choice."* However, as discussed in subsection 5.2, the programmes are not continuing in 2015/16 due to funding cuts.

The DE advises that it is in the "early stages" of considering how to provide CPD in Using ICT to support teachers' confidence in teaching coding. This includes looking at whether the Erasmus+ programme could provide a source of funding for this work.[61]

9   Other jurisdictions

The 2009 *Report of the STEM Review* noted that Northern Ireland was *"playing catch up"* with other countries and jurisdictions in developing a vision of STEM.[62] This section of the report provides information on recent initiatives across the UK, in England, the Republic of Ireland, Scotland and Wales and a number of other jurisdictions.

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[56] European Schoolnet (2014) *Computing our future: Computer programming and coding* Belgium: European Commission
[57] The Royal Society (2012) *Shut down or restart? The way forward for computing in UK schools* London: The Royal Society
[58] Perry, C. (2015) *Coding in Schools* Belfast: Northern Ireland Assembly Research and Information Service
[59] Perry, C. (2015) *Coding in Schools* Belfast: Northern Ireland Assembly Research and Information Service
[60] Minister for Education Answer to an Assembly Question by Mr Peter Weir MLA, 18th September 2014
[61] Information provided by the Department of Education, October 2015
[62] Department of Education and the Department of Employment and Learning (2009) *Report of the STEM Review* Belfast: DE and DEL

9.1 UK-wide: STEM Ambassadors

The STEM Ambassadors programme provides young people with the opportunity to engage with people employed in STEM careers. Ambassadors act as role models and can provide a range of support, including supporting careers events, delivering practical STEM projects and facilitating workplace visits.[63] Programmes are delivered locally and regionally, with national coordination.[64]

9.2 England

The Government is taking steps to attract top STEM graduates into teaching, noting that a shortage of STEM teachers is a long-standing concern.[65] It offers teacher training scholarships and bursaries to high achieving graduates in key subject areas, including science, computing and maths.[66] Bursaries and scholarships include:[67]

- A tax free bursary of £30,000 for graduates with a first class degree training to teach physics;

- Bursaries of up to £25,000 for maths, biology, chemistry and computing; and,

- A further 700 tax-free scholarships, worth up to £30,000, delivered in partnership with professional bodies, such as the Institute of Physics.

The Department for Education emphasises the importance of highlighting STEM career opportunities to pupils.[68] It also focuses on the CPD of teachers. A range of initiatives and policies to increase the uptake of STEM subjects in schools are summarised in Table 2 overleaf.

Table 2 – Government supported initiatives to promote STEM in England

Initiative	Aim	Overview
Your Life campaign	Three year campaign to increase the number of pupils studying maths and physics at	- By August 2015, A-level entries in science and maths had increased by 17.3% since 2010[70] (other factors are likely to have contributed to this) - Aims to recruit highly skilled graduates to teach in schools with

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[63] STEMNET *Ambassadors* [online] Available at: http://www.w5online.co.uk/stemnet/ambassadors/

[64] STEMNET *UK regional contacts* [online] Available at: http://www.stemnet.org.uk/regions/

[65] The Parliamentary Office of Science and Technology (2013), *STEM education for 14-19 year olds*, p. 4

[66] Department of Education and National College for Teaching and Leadership (2015) *National teacher recruitment drive gets underway* [online] Available at: https://www.gov.uk/government/news/national-teacher-recruitment-drive-gets-underway

[67] Gov.uk (2015) *Top graduates to get up to £30k to train to teach core subjects* [online] Available at: https://www.gov.uk/government/news/top-graduates-to-get-up-to-30k-to-train-to-teach-core-subjects

[68] Department for Education (2015) *Careers guidance and inspiration in schools*, p. 6

[70] Department for Education (2015) *Maths entries jump at A level as pupils embrace academic subjects* [online] Available at: https://www.gov.uk/government/news/maths-entries-jump-at-a-level-as-pupils-embrace-academic-subjects

	A-level by 50% in three years[69]	poor science performance, create 2,000 STEM jobs and encourage young people, particularly women, into STEM[71]
Stimulating Physics Network and Further Maths Support Programme	Enhance teaching and learning and increase uptake in A level physics and maths[72]	• Free CPD workshops for physics teachers, mentors and targeted support for schools[73] • Tuition to pupils whose schools do not offer Further Maths[74]
National Centre for Excellence in the Teaching of Mathematics	Improve the teaching of maths	• CPD and collaboration opportunities • 34 maths hubs aiming to increase the quality of maths teaching[75]
National Science Learning Network	Subject specific CPD	• CPD for teachers; teaching assistants and technicians working with pupils aged five to 19 through Science Learning Partnerships and the National Science Learning Centre.[76]

9.3   Republic of Ireland

The Republic of Ireland has introduced a range of policies and curriculum revisions aimed at promoting STEM subjects in schools.[77] Since 2012, a two year part-time programme Professional Diploma in Mathematics for Teaching has been made available nationwide and free of charge. It aims to assist 'out-of-field' teachers to acquire skills for effective maths teaching.[78]

Furthermore, the National Council for Curriculum and Assessment (NCCA) has produced new specifications for Leaving Certificate sciences and Junior Cycle science.

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[69] Department for Education (2014) *Nicky Morgan speaks at launch of Your Life Campaign* [online] Available at: https://www.gov.uk/government/speeches/nicky-morgan-speaks-at-launch-of-your-life-campaign

[71] Gov.uk (2014) *Over 2000 new jobs and apprenticeships from leading STEM organisations* [online] Available at: https://www.gov.uk/government/news/over-2000-new-jobs-and-apprenticeships-from-leading-stem-organisations

[72] HOL Question HL5587, 11 March 2014

[73] Science Learning Network *Stimulating Physics Network* [online] Available at: https://www.sciencelearningcentres.org.uk/audience/secondary-post-16/stimulating-physics-network/

[74] Further Maths Support Programme *The Further Mathematics Support Programme* [online] Available at: http://www.furthermaths.org.uk/

[75] Maths Hubs *About the Maths Hubs Programme* [online] Available at:

[76] National Science Learning Network *About* [online] Available at: https://www.sciencelearningcentres.org.uk/about/

[77] Dáil Eireann, Written Answer 5996/15, 10 February 2015

[78] Dáil Eireann, Written Answer 24307/15, 18 June 2015

CPD will be provided for teachers across both levels in order to support consistency in science teaching.[79] A number of initiatives that have been implemented to increase the uptake of STEM subjects in schools are outlined in Table 5.

Table 3 – Government supported initiatives to promote STEM in the Republic of Ireland

Initiative	Aim	Overview
Discover Primary Science[80]	Foster interest in STEM in primary schools	• Offers CDP for teachers, a framework for science through enquiry, resources and awards
EMC Robotics Initiative[81]	Promote STEM subjects from a young age	• Collaborates with primary schools to design and build their own robots
Smart Futures Programme	Promote STEM at post-primary Three year strategy aiming to increase uptake of STEM by 10%[82]	• Government collaborating with industry and educators to promote STEM careers and role models to pupils[83] • Provides career resources to teachers, parents and guidance counsellors[84]

9.4 Scotland

The Scottish Executive has included STEM education as a key priority for the school curriculum (Curriculum for Excellence).[85] Additionally, the Scottish Executive has stated that it will take action in relation to physics and computing in schools as gender balance in these subjects is "*in serious need of improvement".*[86]

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[79] Dáil Eireann, Written Answer 24307/15, 18 June 2015

[80] Discover Primary Science and Maths *About Discover Primary Science and Maths* [online] Available at: http://www.primaryscience.ie/about.php

[81] *Department of Jobs, Enterprise and Innovation (2014) EMC* robotics initiative to promote STEM learning in primary schools [online] Available at: https://www.djei.ie/en/News-And-Events/Department-News/2014/September/EMC-robotics-initiative-to-promote-STEM-learning-in-primary-schools.html

[82] Science Foundation Ireland (2014)*Three-Year plan to Deliver increase in uptake of science, technology engineering and maths – Minister Bruton* [online] Available at: http://www.sfi.ie/news-resources/press-releases/three-year-plan-to-increase-in-uptake-of-stem.html

[83] Smart Futures (2015) *About Smart Futures* [online] Available at: http://smartfutures.ie/about-smart-futures

[84] Smart Futures (2015) *About Smart Futures* [online] Available at: http://smartfutures.ie/about-smart-futures

[85] The Scottish Government (2014) *Improving STEM (Science, Technology, Engineering and Mathematics) Education* [online] Available at: http://www.gov.scot/Topics/Education/Schools/curriculum/ACE/Science

[86] Scottish Parliament, Question S4W-27501, 24 September 2015

The Scottish Government has also developed policies in relation to the CPD and recruitment of teachers. For example, the Scottish Schools Education Research Centre (SSERC) provides CPD in support of science and technology education.[87] From April 2009 to March 2014, over 92% of post-primary schools and colleges were represented at one or more of SSERC's professional development courses.[88]

The SSERC is also delivering an initiative supported by the Government, which aims to develop primary teachers' confidence and skills in teaching science through practical lessons.[89] In June 2015, £930,000 was awarded by the Government to support SSERC for the development of teachers delivering science and technology subjects.[90]

A recruitment drive for teachers was launched in September 2015 through the Inspiring Teachers campaign. It focusses on attracting teachers to STEM subjects. The campaign will feature "*figureheads from Scottish business, industry, media and science, sharing their memories of the teachers that inspired them and helped them get where they are today.*"[91]

Digital World, supported by Skills Development Scotland, is an initiative aiming to increase the demand for skills within the technology industry. It provides information tailored for school pupils, including advice on subject choices and routes to university for technology careers.[92] It particularly targets women, aiming to challenge stereotypes around STEM.[93]

9.5 Wales

In March 2012 the Welsh Government published *Science for Wales – A strategic agenda for science and innovation in Wales*. It set out a vision for science, engineering and technology, and established STEM as a key priority for the future well-being of Wales. The Government reports on progress against the agenda on an annual basis.

STEM guidance published in September 2012 outlined measures to be taken over the next five years for the recruitment and CPD of teachers, including:[94]

- Continuing to target the supply of high quality graduates, including through incentives into priority areas of STEM initial teacher training;

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[87] Scottish Schools Education Research Centre *Professional Development* [online] Available at: http://www.sserc.org.uk/index.php/cpd-roundup

[88] Scottish Schools Education Research Centre *Professional Development* [online] Available at: http://www.sserc.org.uk/index.php/cpd-roundup

[89] Scottish Parliament, Question S4W-14973, 28 May 2013

[90] The Scottish Government (2015) *Supporting STEM teaching* [online] Available at: http://news.scotland.gov.uk/News/Supporting-STEM-teaching-1a36.aspx

[91] The Scottish Government (2015) *Teacher recruitment* [online] Available at: http://news.scotland.gov.uk/News/Teacher-recruitment-1d77.aspx

[92] Digital World About Digital World [online] Available at : https://www.digitalworld.net/about [Accessed 3 November 2015]

[93] Code Clan (2015) *Digital World* [online] Available at: http://codeclan.com/news/digital-world

[94] Welsh Government (2012), *STEM: Guidance for schools and colleges in Wales*, p. 24

- Continuing to be committed to the provision of CPD for all STEM teachers and to work with partners in developing standards; and,

- Developing and responding to research into science education.

The February 2015 report *Successful Futures*, commissioned by the Welsh Government, examined assessment and curriculum arrangements in schools throughout Wales. It emphasised the importance of STEM and noted that all teachers should have cross-curricular responsibilities in literacy, numeracy and digital competence.[95] Table 4 outlines a range of initiatives that have been implemented to increase the uptake of STEM subjects in schools.

Table 4 – Government supported initiatives to promote STEM in Wales

Initiative	Aim	Overview
National Science Academy	Promote and coordinate STEM at all levels	- Government's main vehicle for encouraging participation in STEM - Awards grant funding to deliver STEM enrichment projects[96]
Techniquest	To engage people with science and motivate them to learn more[97]	- Provision of specialised education programmes linked for the school curriculum - Teachers are provided with resource materials to extend learning on return to the classroom[98]

9.6   Practice and Policy in other EU Member States

This section summarises examples of practice and policy to promote STEM education in other EU Member States.

9.6.1 Finland: cross-sector collaboration

The LUMA Centre Finland was established in November 2013. It aids collaboration of schools, universities and the business sector to promote and support life-long learning,

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[95] Welsh Government (2015) *Now online: Independent Review of Curriculum and Assessment Arrangements in Wales* [online] Available at: http://learning.gov.wales/news/sitenews/successful-futures/?lang=en

[96] Welsh Government (2015) *National Science Academy* http://gov.wales/topics/science-and-technology/science/nsa1/?lang=en

[97] Techniquest (2012) *About Techniquest* [online] Available at: http://www.techniquest.org/20120315131/about-us/about-techniquest.html

[98] Techniquest (2012) *Education programmes* [online] Available at http://www.techniquest.org/2012030113/education/education-programmes.html

studying and teaching of STEM subjects on all levels of education.[99] In April 2014 the Centre launched a national programme that focused on developing STEM education for six to sixteen year olds.[100]

The programme was initiated by the Minister of Education and is scheduled to run until 2019. The Minister is seeking to improve STEM skills and develop the future of basic education in Finland. The programme aims to seek innovative tools and approaches to teaching practices, methods and learning environments.[101]

9.6.2 Denmark: teacher specialisation in STEM

The Danish Government has emphasised the CPD of teachers in public schools. The initiatives aimed to provide teachers with a specialisation in science or maths (although others could be followed). Over 800 teachers gained science subject specialisation and 430 teachers finished courses leading to qualification as science guidance counsellors.[102]

9.6.3 Belgium (Flemish): engagement between students and industry professionals

Belgium promotes engagement between students and industry professionals through the *World at Your Feet Project*. It is aimed at stimulating pupils aged 16-18 to choose STEM subjects at university, and targets students (particularly females) to pursue careers in civil engineering. [103]

10 Conclusion

This paper has highlighted a number of issues around the teaching of science in primary schools. It has also discussed a number of areas that could be given further consideration in relation to progress against the Success through STEM strategy.

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[99] Luma Centre Finland (2013) *A brief introduction to LUMA* [online] Available at: http://luma.fi/news/2196/a-brief-introduction-to-luma

[100] Luma Centre Finland (2013) *Luma Centre Finland chosen to launch national STEM education development programme* [online] Available at: http://www.luma.fi/news/2940/

[101] Luma Centre Finland (2013) *Luma Centre Finland chosen to launch national STEM education development programme* [online] Available at http://www.luma.fi/news/2940/

[102] European Parliament (2015) *Encouraging STEM Studies for the Labour Market, p. 28*

[103] European Parliament (2015) *Encouraging STEM Studies for the Labour Market, p. 29*

Further consideration could be given to:

- The evidence that many primary teachers do not feel equipped to teach STEM;

- The lower teaching time for primary science in Northern Ireland compared to other countries internationally;

- The low proportion of primary teachers emphasising science investigation in their lessons;

- The low proportion of primary pupils availing of the STEM Module;

- The reasons for the disparate findings at A level in terms of the increasing proportion of exam entries in STEM subjects, while there is a decline in the proportion of students entering one or more STEM exam;

- The decline in the proportion of A level students taking one or more STEM exams in light of the DE Corporate Plan goal to increase the proportion by 5%;

- The decline in pupil performance in maths from primary to post-primary education and the proportion of post-primary students achieving low maths scores in PISA;

- The higher proportion of male students studying STEM;

- Concerns around inadequate access to CPD in STEM and recent funding cuts;

- The decreasing number of enrolments in STEM courses in ITE;

- Concerns around STEM careers advice and guidance in schools; and,

- Practice in other jurisdictions, such as bursaries aiming to attract high performing STEM graduates to teaching.