STEM Education 2020:
Reporting on Practice in Early Learning and Care, Primary and Post-Primary Contexts

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Inspectorate

Department of Education

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1 Introduction

1.1 Purpose of this report

This report presents the findings of an Inspectorate evaluation of the implementation of the first phase of the *STEM Education Policy Statement 2017-2026* in a sample of Early Learning and Care (ELC) settings, and primary and post-primary schools during the period January 2019 to December 2019. The intended audience for this report includes teachers and practitioners in schools and early learning and care settings, providers of initial teacher education and of continuing professional development (CPD) across the various sectors, and policy makers in the Department of Education and other relevant Departments. The evaluation focuses on three key questions:

1 How effectively are learners in early learning and care, and primary and post-primary settings engaging with Science, Technology, Engineering and Mathematics (STEM) education?

2 How effectively are education practitioners and teachers engaging with STEM education methodologies?

3 How well are national STEM education goals being realised at school/setting level?

In addition, the report draws on other data relevant to STEM education in Ireland today including:

- Student participation in STEM areas of learning

- Use of digital technologies to support STEM education

- National and international STEM education performance data.

More broadly, this report is designed to provide a benchmark for the education system and policy makers in relation to how STEM education policy is being implemented at school and early learning and care setting level and to inform actions that may need to be taken to ensure that national STEM education objectives can be achieved. In addition, the report is intended to be a resource for early years education practitioners and for primary and post-primary teachers through providing illustrations of effective STEM education as observed in the course of the evaluation project.

1.2 Background

Science, Technology, Engineering and Mathematics (STEM) are key enablers for the Irish economy and for the development of important skills and competencies in our young people. STEM is an ever-evolving area and the skills and learning associated with STEM education will help to prepare our young people for the crucial role that they have to play in the future success of Irish industry and research and development.

STEM education actively promotes and develops learners' creative and critical thinking skills, skills that are essential for the next generation. Not only does STEM education promote these skills, it also supports the development of life skills, ingenuity and problem-solving and it promotes empathy for issues including sustainability and the natural environment. Now more than ever it is apparent that STEM education is crucial to the health and wellbeing of our citizens. Innovative and creative approaches to problem-solving during the COVID-19 pandemic demonstrated how STEM education can prepare our society to address challenges facing us as a society. From the 3-D printing of medical face shields in Irish classrooms, to the design and manufacture of ventilators on car assembly lines incorporating adapted windscreen wiper motors, STEM approaches have been a crucial part of a truly global cause.

Careers based in the STEM arena are therefore often some of the most interesting, fulfilling and innovative careers available. Today's children have already witnessed technologies that were once thought of only in the realm of science fiction. The future development of autonomous vehicles, the internet of things (IoT) and augmented reality (AR) are all areas that provide our children with an unrecognisable career vista. It is thought that more than 60% of children attending school today will work in a career that does not currently exist. Our role in STEM education is to ensure that our children are equipped to adapt to the new possibilities that a STEM education will bring them. To prepare for this new reality, the Irish Government commissioned the STEM Education Review Group, chaired by Professor Brian MacCraith, to compile a *Report on Science, Technology, Engineering and Mathematics Education* which was published in November 2016. That report identified a number of key issues and proposed actions in areas such as initial teacher education (ITE), continuing professional development for STEM teachers and practitioners, the introduction of

new teaching methodologies, and the use of information and communication technology (ICT) in order to support STEM education in schools and to promote STEM careers. Crucially it highlights the vision that STEM learning is for all learners and should go beyond early learning and care settings and the primary and post-primary classrooms, and crucially be part of the life-long learning experience for teachers.

Against the backdrop of the *Report on Science, Technology, Engineering and Mathematics Education*, the Department of Education and Skills developed its *STEM Education Policy Statement 2017-2026*. That policy statement and its associated *STEM Education Implementation Plan 2017-2019* outline high level actions and sub-actions aimed at developing and improving STEM education in Ireland.

This report endeavours to provide meaningful benchmarks for STEM education in the context of the *STEM Education Policy Statement* and the *STEM Education Implementation Plan*. It focuses in particular on the impact that the national policy and implementation plans have had at school and pre-school level during the Enhancing Phase (2017-2019) of the national policy.

1.3 STEM Education: The Early Learning and Care (ELC) context

At the core of *Aistear: the Early Childhood Curriculum Framework* is the enabling of children to learn by exploring and investigating their environment through play. Great value is placed on enabling the pre-school child to experiment using hands-on materials. Children's exploration, questioning and problem-solving through play and investigation underpin their development of basic concepts in Science, Technology, Engineering, Arts and Mathematics. It is important that all concepts and skills are framed in a playful way and that children have freedom to choose the tasks and activities in which they wish to engage. A skilled early learning and care practitioner can enrich learning by asking the right questions and stimulating investigations where children are identifying objects, making comparisons, predictions, testing hypotheses and sharing discoveries; all while observing their natural environment. In addition, children in early learning and care settings view the process as being more important than the outcome; this makes them prime candidates to take on the role of explorer, scientist and investigator. In short, their natural and innate curiosity about the living world is a strong internal motivator as they search with enthusiasm for answers to their own questions.

While, as outlined below, there is a range of supports for primary and post-primary schools in developing STEM pedagogies and facilitating STEM learning experiences, supports for early learning and care settings are, understandably, at an earlier stage of development. It is anticipated that with a new awareness of the value of the foundations for STEM education in the ELC sector, STEM learning practice can become systematic and embedded.

1.4 STEM Education: The primary context

A significant backdrop to STEM education at primary level is the integrated nature of the Primary School Curriculum with its focus on the development of learners' skills, knowledge and dispositions in a holistic, cross-curricular way. Primary schools offer a wide variety of subjects which are very often taught thematically. In all, there are eleven mandatory curriculum

subjects at primary level, including Mathematics and Science. The science curriculum, which encompasses the content strands of *Living Things*, *Energy and Forces*, *Materials*, and *Environmental Awareness and Care*, specifically supports the development of skills related to designing and making and working scientifically. These skills include the skills of questioning, observing, predicting, investigating and experimenting, estimating and measuring, analysing, recording and communicating. The mathematics curriculum requires the development of similar and further skills including problem solving, integrating and connecting, reasoning and implementing.

In addition to Mathematics and Science, other areas of the curriculum such as Geography and Visual Arts have clearly identifiable STEM components. Indeed some school systems have emphasised creativity, innovation and learning in the Arts as essential within a STE(A)M framework. Primary school pupils are taught typically by one teacher throughout the school week and it is considered good practice for these teachers to plan for linkage and integration of topics within and across subjects/curriculum areas. This thematic approach underpins effective STEM learning in primary schools. The scientific skills of *Working Scientifically* and *Designing and Making* are developed as children engage in scientific investigations, and as they explore materials and plan, design and make models that provide solutions to practical problems. This helps to demonstrate how STEM learning can be fostered across the primary curriculum in a way that promotes creativity and integrated STEM learning.

The primary STEM education context has been developing gradually over recent years. The Professional Development Service for Teachers (PDST[1]) is increasingly raising the awareness of STEM-related activities by providing ongoing CPD in associated areas and through social media. PDST supports teachers in the implementation of principles and practices of STEM education in the classroom through a wide range of CPD models including interdepartmental work at school level where teachers of different STEM disciplines plan and teach together. There are many positive initiatives supporting STEM in primary schools currently. These initiatives include Discover Primary Science and Maths Programme, the Primary Science Fair, ESB Science Blast, Maths Week, Science Week and Engineers' Week. These initiatives to support STEM provision in primary schools also support national STEM education policy more broadly. The enhancement of digital technologies and information and communication technology in primary schools has also complemented and supported STEM provision in classrooms. In addition, a number of primary teachers throughout the country have been promoting aspects of STEM innovatively in their schools through their own personal interests or qualifications in the STEM subjects. The national policy has brought STEM into focus for all primary schools, although schools are at different stages of STEM education provision and development.

1.5 STEM Education: The post-primary context

An important factor in the STEM education post-primary context is how subjects at post-primary level are offered, with some subjects being mandatory and others optional. STEM subjects are situated generally in both the mandatory and optional subject areas. Mandatory subjects include Mathematics in all schools; a number of schools also require all students to study Science at Junior Cycle. Generally, subjects such as Engineering, Technology, Graphics subjects and Wood and Construction subjects are optional. Other science-based subjects including Chemistry, Biology and Physics may also be optional, depending on a particular

1   https://pdst.ie/schoolsupport

school's curriculum at senior cycle. Whilst still a challenge for some schools, STEM subjects are becoming more available for students in voluntary secondary schools, in community/comprehensive schools, and in Education and Training Board (ETB) schools. New post-primary schools are often provided with specialist technology rooms, making access to these subjects more achievable than ever before.

Teachers deployed by schools to teach STEM subjects are becoming more and more specialised and qualified in their subject areas particularly since the establishment of the Teaching Council. The Teaching Council's oversight of the accreditation of initial teacher education (ITE) programmes for primary and post-primary teaching which are provided by Higher Education Institutions has been very significant in underpinning the quality of preparation for beginning teachers, especially in specialised areas such as STEM. The Teaching Council's national framework for teachers' learning, (Cosán), seeks to ensure that all teachers are enabled to engage in high-quality professional learning and development that maintains their expertise and skill levels and supports student learning. Continuing professional development courses for teachers have been instrumental in upskilling teachers across the STEM subjects with significant training provided in recent years in the areas of Project Maths, Technology at Senior Cycle, and Design and Communication Graphics. The PDST has enabled teachers to access ongoing CPD in a wide variety of STEM subject areas. At the same time, Junior Cycle for Teachers (JCT), a support service for post-primary schools, has been instrumental in equipping post-primary teachers with the additional skills and expertise required to adapt and adopt the new approaches to STEM envisaged as part of Junior Cycle Reform.

2 The Evaluation Project

2.1 Focus

The Inspectorate of the Department of Education evaluates and reports on the quality of educational provision for learners in early learning and care settings, schools, centres for education and other settings. The Inspectorate also provides advice and support to early learning and care practitioners, teachers and those involved in the leadership, management and patronage or ownership of these settings in relation to actions that need to be taken to improve education provision. Through discussion, reporting and publication, the Inspectorate disseminates the findings of its evaluations and publishes advice on how the work of education providers and the learning of children and young people can be improved. This STEM evaluation report is designed to:

- Encourage and facilitate discourse around the current quality of STEM education in schools and early learning and care settings

- Provide illustrations of good STEM practices in all three sectors - early learning and care, primary and post-primary

- Provide baseline information about STEM education in order to inform further implementation of national policy on STEM education and against which future progress in implementing the policy can be assessed.

This report explores the three key questions below by drawing on findings from evaluations in a sample of early learning and care, primary and post-primary settings and referencing relevant national and international STEM-based research.

> 1 How effectively are learners engaging with STEM education?
>
> 2 How effectively are teachers and practitioners engaging with STEM education methodologies?
>
> 3 How well are national STEM education goals being realised at school/Early Learning and care (ELC) setting levels?

In addressing these three questions, the report also draws on other data relevant to STEM education in Ireland today such as:

- Student participation in STEM areas of learning

- Use of digital technologies to support STEM education

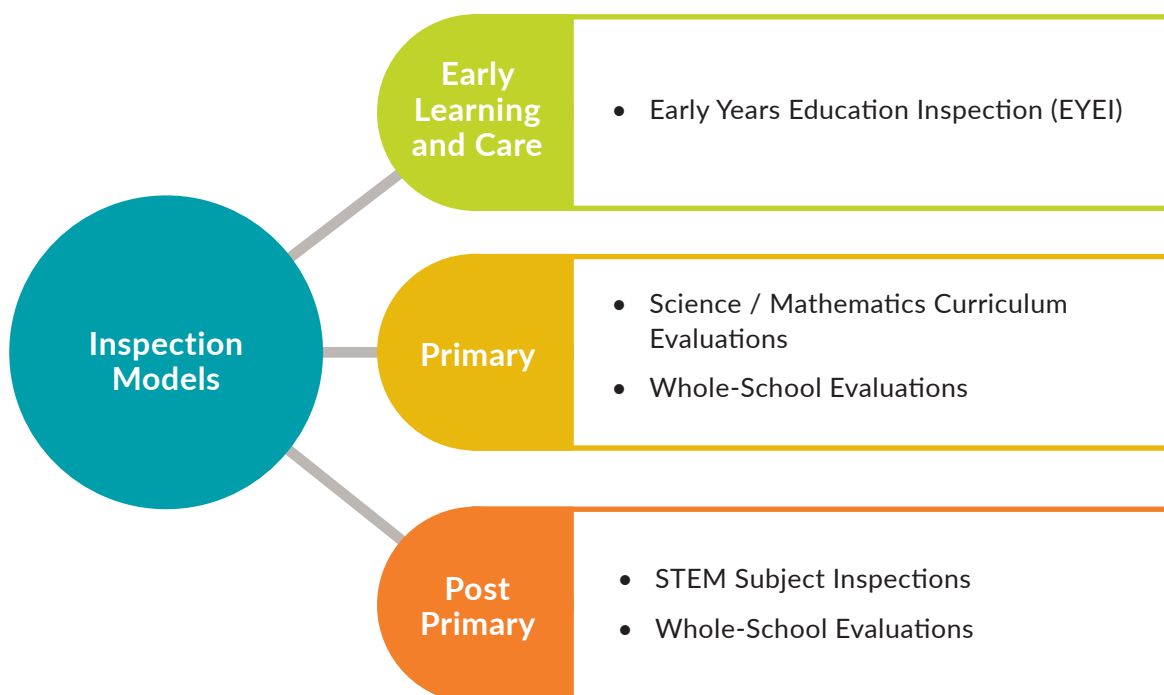- National and international STEM education performance data.

2.2 Methodology

A STEM education working group comprising early learning and care, primary and post-primary inspectors was convened in late 2018. This group set about gathering information, observing practice and discussing schools' and settings' approaches to STEM education in the context of the *STEM Education Policy Statement and Implementation Plan*. As part of this work, inspectors ascertained the overall quality of STEM education provision in the sample of schools and ELC settings they visited. Initially, the Inspectorate developed a small number of focused STEM-related evaluation criteria to be incorporated into inspection instruments. The first step in this process was the identification of indicators of good practice in STEM education. Those indicators were framed primarily within the contexts of classroom experiences and whole setting/school level culture. The STEM-focused evaluation criteria were utilised then in a sample of evaluations in early learning and care settings, primary schools and post-primary schools.

Figure 1 outlines the models of inspection that were incorporated into this project in the three sectors (early learning and care settings, primary and post-primary schools).

A total of 101 schools and settings were visited during the course of the project. *Figure 2* provides a breakdown of the 101 settings/schools visited and of the 218 sessions/lessons observed during those visits. In addition to observing teaching and learning in the schools/settings they visited, inspectors discussed STEM education with the setting/school management and with teachers/practitioners. As Figure 1 shows, a broadly similar number of visits took place across the three sectors.

Figure 1: Inspection Models and Subject Areas Included in Project

Inspection Models

Early Learning and Care
- Early Years Education Inspection (EYEI)

Primary
- Science / Mathematics Curriculum Evaluations
- Whole-School Evaluations

Post Primary
- STEM Subject Inspections
- Whole-School Evaluations

In each of the three sectors, a number of sessions/lessons were observed to gather STEM-related information. One session was observed for this purpose during each of the early learning and care settings visited. Approximately two lessons on average were observed through the lens of STEM in each primary school visited, and on average, three lessons were observed from the perspective of STEM in each post-primary school.

Figure 2: STEM Evaluation Project Scope

Sector	Settings/Schools	Sessions/Lessons
Early Learning and Care	29	29
Primary	40	94
Post-primary	32	95
Total	101	218

Care was taken to ensure consistency and inter-rater reliability among inspectors in relation to the application of the STEM-focused evaluation criteria. All of the criteria were reviewed by inspectors from all three sectors (early learning and care, primary and post-primary) and the approach to applying the criteria was standardised and reported on using the Inspectorate's quality continuum.

Figure 3: Inspectorate Quality Continuum

Rating	Description
Very Good	*Very good* applies where the quality of the areas evaluated is of a very high standard.
Good	*Good* applies where the strengths in the areas evaluated clearly outweigh the areas in need of improvement.
Satisfactory	*Satisfactory* applies where the quality of provision is adequate.
Fair	*Fair* applies where, although there are some strengths in the areas evaluated, deficiencies or shortcomings that outweigh those strengths also exist.
Weak	*Weak* applies where there are serious deficiencies in the areas evaluated.

3 How effectively are learners engaging with STEM education?

3.1 Overall findings

Overall, inspectors found that learners were provided with many opportunities to engage with STEM activities that foster and support effective STEM learning and development. In all sectors, learners' participation in STEM education was rated as satisfactory or better in not less than 79% of the sessions/lessons observed. This is a significant finding particularly in the context of the early learning and care (ELC) sector. While the primary and post-primary lesson observations took place largely in the context of STEM subjects, the session observations in early learning and care settings occurred in more generic learning contexts that were not focused primarily on STEM. The integrated curricular approach provides more opportunity for an inter-disciplinary and multiple intelligence approach to teaching and learning, particularly when desired outcomes include STEM competencies and teaching for understanding. It is also noteworthy that in approximately one in every five sessions at early learning and care level, and one in every five lessons at post-primary level, learners' participation in STEM education was deemed to be less than satisfactory. This finding, particularly at post-primary level, is a cause for concern as students in the STEM post-primary lessons observed were perfectly placed to experience STEM education in a real and meaningful way through their engagement with the STEM subjects observed.

Figure 4: Learners' Participation in STEM activities
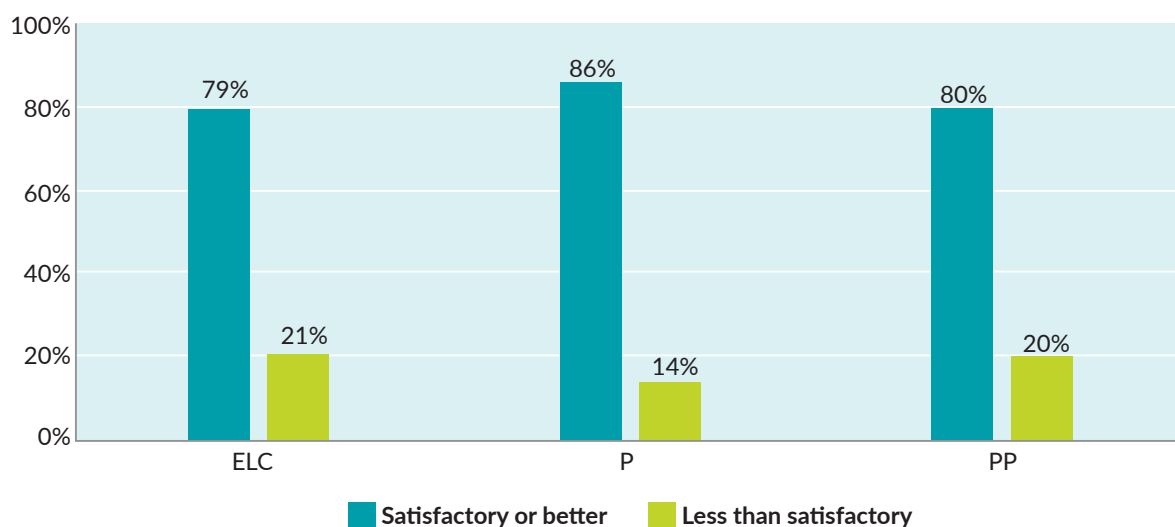
The quality of learning achievements in lessons/ELC sessions was also examined. At both primary and post-primary levels, learners' achievements were identified as satisfactory or better in over 80% of the lessons observed. Findings in relation to learners' STEM achievements during the early learning and care sessions observed were somewhat less positive with 28% of the sessions observed deemed less than satisfactory.

Figure 5: Quality of Learning Achievements
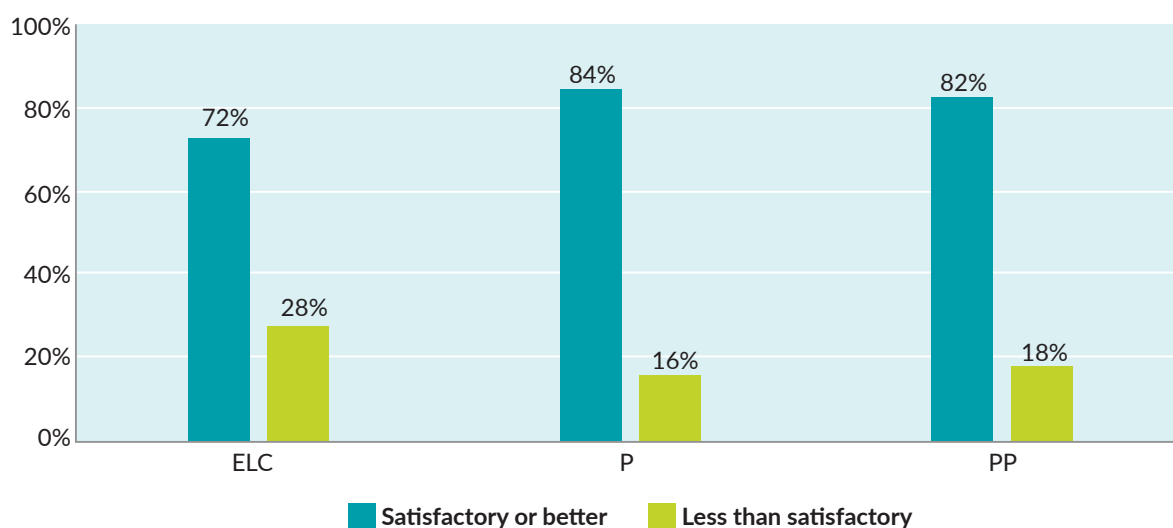
3.2 Spotlights on effective STEM learning experiences

In early learning and care sessions where children's engagement and learning achievements in STEM were satisfactory or better, children were engaging typically in a variety of activities that fostered creativity and critical thinking skills. The children were enabled to be natural discoverers, inquirers, engineers and explorers. In leading their own learning in a well-prepared environment, children could, for example, collect stones, compare the size and weight of objects and build forts out of recycled materials. The natural enthusiasm of these very young children was captured and channelled through appropriate activities. These activities were facilitated by supportive, engaged practitioners who were skilled in identifying STEM-teaching moments. Practitioners identified children's interests and built deeper understanding in partnership with the children through the use of open-ended questions and by expanding and supporting the children's acquisition of new language.

It is important that early STEM education is age and stage appropriate and that the inclusion of play and the manipulation of materials to develop STEM thinking are a foundation stone in the development of learners' STEM education experiences. Young children must have strong STEM experiences to spark their interests and to help them build the foundational skills necessary to propel them into their STEM futures. As researchers at Indiana University[2] have shown, playing with building blocks helps children to develop their spatial reasoning skills. This is reinforced by researchers in Johns Hopkins Center for Talented Youth where they show that simply by playing with and physically manipulating blocks, key STEM skills like inquiry, experimentation

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2   Sharlene D. Newman, Mitchell T. Hansen, Arianna Gutierrez. An fMRI Study of the Impact of Block Building and Board Games on Spatial Ability. Frontiers in Psychology, 2016

and theorising—all key components of the scientific method—are embedded.[3] Many of these positive features of engagement and achievement in STEM were evident in a number of the primary classrooms visited.

STEM Learning Spotlight 1

In one lesson in a senior infant classroom, children's creativity and imaginations were sparked when asked to design a new raincoat for the classroom flamingo, 'Sprinkles'. Sprinkles, a large cuddly toy, needed to collect new items for the classroom nature table, but as the weather was really wet outside the children needed to help Sprinkles to make a new coat from a suitable material. A wide variety of materials was supplied for the children and a 'fair test' was devised to test the materials' capacities to keep Sprinkles dry. Each group carried out the test and investigated the materials' waterproofing properties. Each group identified its preferred material and set about making a coat to protect Sprinkles from the elements. The concept of protective barriers was later incorporated into the teaching and learning associated with autumn where horse chestnuts and hedgehogs provided real-world, first-hand examples of the earlier learning.

At primary school level, engagement with a wide variety of STEM experiences is essential for ongoing STEM learning, particularly in forming positive dispositions towards STEM education and promoting life-long learning in the area. Research from the University of London[4] identifies a variety of factors affecting children's aspirations in relation to pursuing science-based careers, and echoes research from King's College London[5] which states that by the age of fourteen, children have already formed their individual feelings about science and any potential career aspirations in STEM.

Overall, where learner engagement and achievement in STEM were found to be most effective at primary level, learners were enabled to explore, investigate and to create using thematic or cross-curricular approaches that encompassed a variety of subjects, activities and approaches.

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3   https://youtu.be/XBS2JrXEmqM

4   2018, Sheldrake, R. *Changes in Children's Science-Related Career Aspirations from Age 11 to Age 14*
    https://link.springer.com/content/pdf/10.1007%2Fs11165-018-9739-2.pdf

5   2012, Archer,L. DeWitt, J. Osborne,J. Dillon, J. Willis, B. Wong, B. *Science Aspirations, Capital, and Family Habitus: How Families Shape Children's Engagement and Identification With Science American Education Research Journal, Vol. 49, No. 5 (Oct. 2012), pp. 881-908.*

STEM Learning Spotlight 2

An illustration of the effectiveness of enabling learners to explore, investigate and create in the promotion of STEM was noted during a fifth-class lesson based on the human digestive system. This lesson was introduced using an audio-visual clip that the teacher and pupils used to stimulate the creation of a rap song using the language learned directly relating to the digestive system. This type of performing arts element provided pupils with a fun and creative way to integrate the newly acquired technical terminology associated with the topic at hand whilst also demonstrating their artistic creativity. Using a workstation approach, pupils then took part in a design-and-make activity where they explored the different parts of the digestive system using play dough. They used their mathematical skills to investigate how saliva helped with swallowing and the breakdown of food and they experimented with ways to demonstrate peristalsis. This multi-faceted approach created an interesting and engaging learning experience for the pupils through scaffolded exploration and hands-on creativity.

At post-primary level, high-quality engagement by students in STEM and positive learning outcomes were most prominent in lessons where students were encouraged to engage in interesting and thought-provoking design-based tasks.

STEM Learning Spotlight 3

In one post-primary school and as part of a Junior Cycle STEM short course, groups of students were required to design and create a roller coaster from semi-tubular foam using a limited number of additional resources provided by their teacher. Each student was given a role including the engineer, designer, researcher and the team leader. The creations made in response to the brief were both ingenious and innovative. When finished, students used marbles to test their roller coasters and recorded the tests on their mobile devices. From these recordings, students then calculated the average speed, velocity and acceleration of the marbles and graphed their solutions. The incorporation of open-ended solution focused tasks, hands-on enquiry based learning, meaningful collaboration, and the integration of mathematical and scientific content created an excellent learning experience grounded in STEM education.

3.3 Other STEM engagement indicators: Uptake and awareness of STEM

When focusing on learner engagement in STEM education, a number of other indicators of success are relevant. The *STEM Education Implementation Plan 2017-2019* identifies a number of key goals in this regard: improved levels of uptake of STEM subjects, uptake by female students of STEM subjects, and awareness of the importance of STEM. The following section of this chapter considers how a number of these goals are being achieved during the Enhancing phase of the *Implementation Plan*.

3.3.1 Uptake of Leaving Certificate STEM subjects

Indicator of Success
Increased uptake of Leaving Certificate Chemistry, Physics, Technology and Engineering by 20%[6]

One key deliverable of the *STEM Education Policy Statement 2017-2026* is an increase in the uptake of Leaving Certificate Chemistry, Physics, Technology and Engineering by 20% over the lifetime of the Policy Statement. The analysis in *Figure* 6 shows that there has been a slight increase in student uptake of these four subjects in 2019 when compared with 2016. The real increase in uptake across the four subjects is 1,098 students or 5%. While this is a welcome increase, it is less than that required in order to reach the goal of a 20% increase by 2026. However, significant growth has been achieved in Technology with a 32% increase in uptake, totalling 456 more students taking Leaving Certificate Technology in 2019 when compared with 2016.

Figure 6: Uptake of Leaving Certificate Physics, Chemistry, Technology and Engineering 2016 and 2019

Subject	2016	2019	Real Increase	% Change
Physics	7,753	7,942	189	2%
Chemistry	9,089	9,506	417	5%
Engineering	5,379	5,415	36	<1%
Technology	1,415	1,871	456	32%
Total	23,636	24,734	1098	5%

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6   STEM Education Implementation Plan 2017-2019 p. 4

3.3.2 Uptake of STEM subjects by female students

Indicator of Success
Increased uptake by females of STEM subjects by 40%[7]

Another key deliverable in the Policy Statement is a 40% increase in the uptake of STEM subjects among females. In the Junior Cycle/Certificate STEM subject areas of Wood Technology, Technical Graphics, Metalwork, Technology and Science the number of females sitting Junior Certificate/Cycle examinations has increased from 32,917 in 2016 to 36,971 in 2019. This overall increase of 4,054 in the number of females sitting these subjects represents a 12% increase since 2016.

Figure 7: Junior Cycle STEM Female Uptake
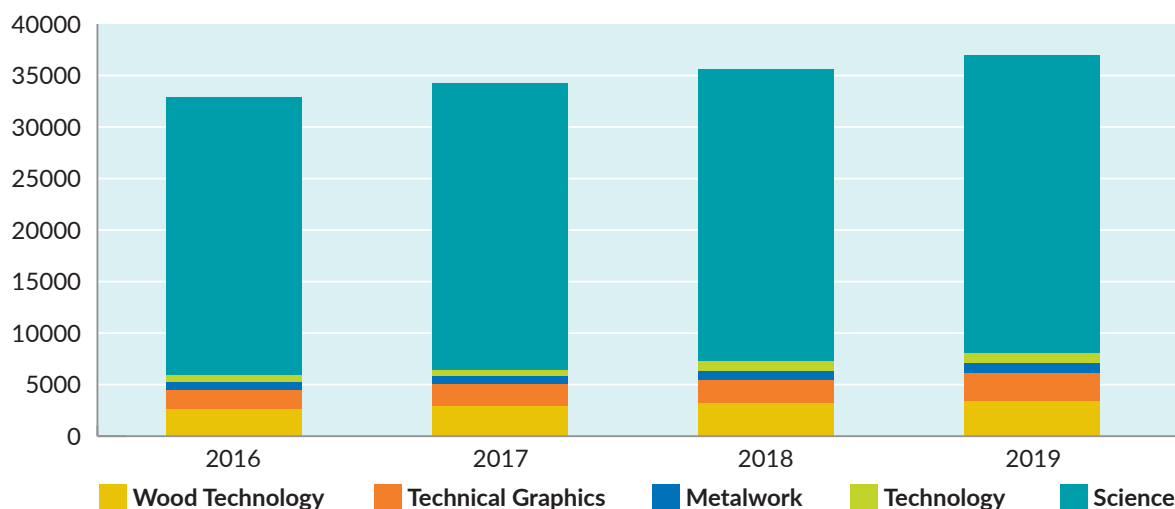
Each of the subject areas has seen an increase in female uptake (*Figure 8*). The largest numerical increase has been in Science with an increase of 1,939 female students taking the subject when compared to 2016 figures. Technical Graphics (TG) has also seen a significant proportional increase in the number of females choosing the subject. A total of 854 more females sat the Junior Certificate examination in TG in 2019 than in 2016. This is a 47% increase based upon the 2016 figures. Whilst these figures are encouraging, there is still work to do in order to achieve the 40% increase envisioned over the lifetime of the Policy Statement with a need to have a larger increase in the STEM subjects outside of the sciences.

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7   STEM Education Implementation Plan 2017-2019 p4

*Figure 8: Increase in numbers of female students taking STEM subjects in Junior Cycle Examinations 2016 - 2019*

Subject Area	Real increase 2016-2019	% Increase 2016-2019
Wood Technology	786	30%
Technical Graphics	854	47%
Metalwork	188	25%
Technology	287	41%
Science	1,939	7%
Total	4,054	12%

3.3.3 Awareness of STEM policy

Indicator of Success

All schools, early learning and care settings, learners and parents to have increased awareness and appreciation of the importance, value and opportunity in STEM with particular focus on females[8]

In general, schools were very aware of the importance of STEM education and there was often a clear articulation by schools of the importance, value and opportunities that STEM education holds for students. This was prevalent at post-primary level particularly, where awareness of STEM education was identified as satisfactory or better in 94% of schools visited. Similarly and positively, at primary level, 88% of schools visited were deemed to be very aware of the national STEM education agenda.

In a significant minority of the early learning and care settings visited, inspectors found that there was a lack of awareness amongst practitioners of the national STEM education agenda and the associated policy statement and implementation plan. Almost one in every three settings visited was deemed to have a less than satisfactory awareness of the STEM education agenda.

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8   STEM Education Implementation Plan 2017-2019 p4

Figure 9: School/Setting Awareness of STEM Education
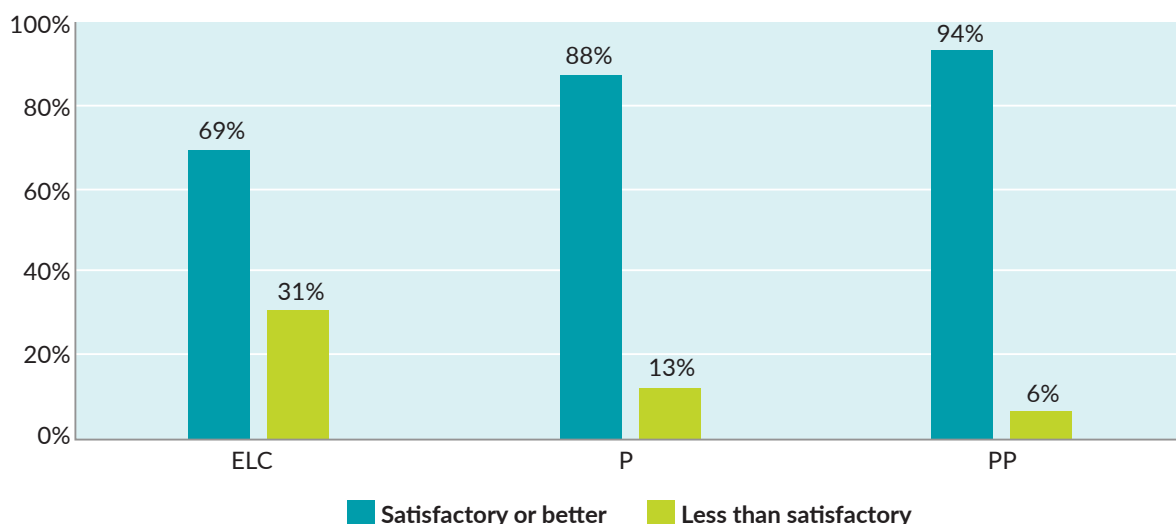
In schools where leadership and teachers placed a clear focus on STEM education, appropriate training opportunities were identified for teachers and an integrated approach to fostering and enhancing the learners' STEM experiences at classroom/session level was evident. In addition, a number of post-primary schools had made a concerted effort to raise student awareness of the value of STEM education and its relevance for life and for potential careers.

STEM Learning Spotlight 4

One school's response to the national STEM agenda mirrors the positive approaches taken across the country in many schools and settings trying to raise awareness of STEM education among their students. This particular school took a number of pro-active steps to ensure that its all-female cohort is given a meaningful opportunity to achieve in the STEM arena. Those steps included the introduction of Agricultural Science in Transition Year (TY) and at Leaving Certificate level. To address potential gender stereotyping, the school also invited female role models, whose educational and careers paths have led them to STEM-based professions, to speak with the students. This strategy was strengthened by the school's commitment to providing its students with access to STEM-focused co-curricular competitions and to regular visits to local STEM-based industries. In addition, work-experience programmes were identified by the school as areas where students could attain relevant and meaningful experiences in STEM industries and associated careers.

Raising awareness of, and participation in, the range of STEM subjects is essential to ensure that we are developing young people who are creative and critical thinkers and also in terms of developing the STEM competencies that our workforce will need. Early learning and care, primary and post-primary educators all have an important role to play in enabling learners to develop the skills and competencies necessary to enter the STEM workforce. Data released by the Central Statistics Office (CSO) in 2017 paints a positive picture regarding our third-level graduates. In 2016, the number of STEM graduates in Ireland was 28.9 per 1,000 persons aged between 20-29 years. This rate was the second highest in the European Union (EU).

Critically, Ireland also had the second highest gender differential in the EU at 24.7, with 41.3 male STEM graduates per 1,000 persons aged 20-29, compared with 16.6 for females. This gender inequality is identified as an area where Ireland must make significant improvements.

4 How effectively are practitioners engaging with STEM education methods?

4.1 Overall findings

Overall, findings in relation to teachers' and practitioners' engagement with, and use of STEM pedagogies were good. In more than four out of every five lessons at both primary and post-primary levels, STEM teaching was deemed to be satisfactory or better. Findings in the early learning and care context were also generally positive with STEM-education pedagogy being deemed to be satisfactory or better in 72% of the sessions observed. These outcomes also point towards further scope for improvement in teaching processes and approaches and in scaffolding learning related to STEM.

Figure 10: STEM Teaching

Legend: ■ Satisfactory or better   ■ Less than satisfactory
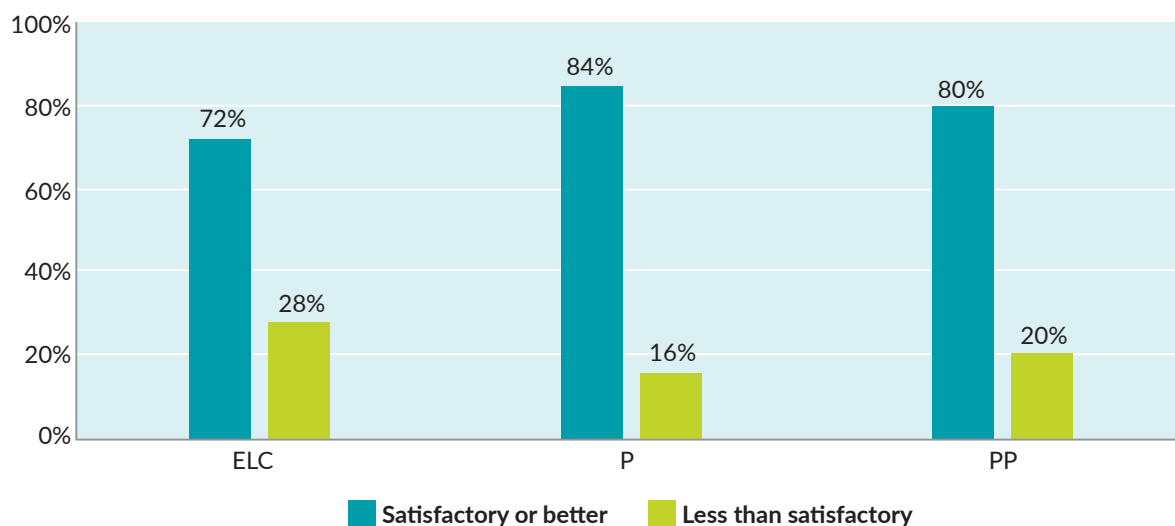
4.2 Spotlights on effective STEM pedagogies

In the more effective STEM lessons observed in primary schools, teachers maximised the potential for children to develop their sense of wonder and natural curiosity; children's agency in their own learning was facilitated skilfully and the children were enabled to use the environment to explore, observe, and experiment with natural and other materials.

STEM Learning Spotlight 5

In one primary school, pupils were focusing on the school's response to pollution and their responsibility for the environment as a whole. Led by the school's Green School team, pupils carried out an analysis of the air pollution around their school throughout the day. The aim of the project was to use the data already available in relation to the quality of air around schools at different times of the school day and apply it to their own situation. Pupils recorded data in relation to cars idling outside their school at the beginning and end of the school day. They used this rich data to inform their parents of the increase in air pollution while their vehicles were idling in the carpark. The teacher's integration of various aspects of the curriculum in this way enabled the pupils to use, in a real and meaningful way, mathematical skills in measuring, recording and displaying results, and scientific exploration skills in analysing and comparing results. The integration of these skills had the effect of reducing exhaust emissions in the school's local environment and demonstrated how the pupils could make a meaningful impact in their own locality.

Where high-quality STEM teaching at post-primary level was observed it was often characterised by an openness to multiple solutions, the incorporation of digital tools to support teaching and learning, the use of enquiry-based methods and engagement with an engineering design process.

STEM Learning Spotlight 6

One notable example of effective STEM teaching at post-primary level was observed as part of a Junior Cycle school-developed short course. Students enrolled in this module experienced a variety of learning strategies across the STEM-based disciplines. The module was developed through a local partnership with a wildlife park. Teachers developed a design, build and test project that required students to work collaboratively to create an enrichment tool for a species of animal of their choice. These tools help to encourage the animals' cognitive and physical activity and often incorporate food as a reward for their persistence. This project involved students researching the wildlife and their particular needs and requirements. Their teachers guided their progression, using an engineering design process to design, prototype, test and build operational enrichment tools for animals as diverse as ring-tailed lemurs and zebras. Flexible timetabling enabled group work to occur across a variety of subject areas simultaneously thereby enabling students to investigate relevant topics and ultimately to test potential solutions. The teachers' flexible approach enabled students to engage in highly effective group work where they worked collaboratively to solve design-based problems. The integrated nature of this short course maximised the skills that students could draw upon to creatively solve a problem.

In post-primary lessons where STEM teaching practices were less developed, one-dimensional approaches to teaching and learning were most common. Teachers were less likely to promote exploration and creativity and more likely to focus on teacher-guided solutions and teaching strategies that resulted in single-answer solutions. This binary approach provides learners with limited flexibility and can have detrimental effects on learners' innate curiosity particularly if they do not get the "right answer".

STEM education, whilst made up of a variety of distinct disciplines, is at its heart, multi-disciplinary and inter-disciplinary. In a significant number of post-primary STEM subject lessons, an integrated approach to STEM teaching was absent. This greatly increased the risk of STEM subject learning developing in isolation, without context and without opportunities for integration with other STEM subjects being studied.

It is also critical for learners at all levels—early learning and care, primary and post-primary—to have opportunities to make tangible links with real-life problems in order to advance their STEM learning in a meaningful way. Opportunities for learners to focus on hands-on building and problem-solving activities are critical for positive learning outcomes. Research carried out as part of the OECD's *Fostering Students' Creativity and Critical Thinking What it Means in School*[9] study highlights problem-solving and the inclusion of design-based learning as crucial in an inter-disciplinary approach to teaching and learning. This approach encourages creativity and the identification of innovative solutions to complex real-world problems through a process of Design Thinking[10].

Figure 11 sets out a number of questions designed to support education practitioners in reviewing or self-evaluating their STEM pedagogies.

Figure 11: STEM Methodology Questions

Do activities focus on real-world issues and problems?	Are lessons supportive of "Design Thinking" approaches?	Is hands-on inquiry and open-ended exploration encouraged?	Are students given the opportunity to work together as a team?
Is mathematical and scientific content integrated into learning?	Are multiple approaches and solutions encouraged?	Are subject links and partnerships utilised in lessons?	Is Art incorporated into the appearance, design and usability of a project?
Is digital learning used to support STEM based activities?	Is artistic and creative planning for solutions used to overcome an engineering problem?	Are links with local STEM industries and research facilities embedded?	Are work experience opportunities for students in STEM based industries / services tilised?

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9   https://read.oecd-ilibrary.org/education/fostering-students-creativity-and-critical-thinking_62212c37-en#page105

10 Design thinking instruction is comprised of three core features: 1) a flexible learning space; 2) teamwork 3) a systematic approach on problem solving.

4.3 Planning for STEM Education and the use of data

When focus is placed on the STEM pedagogies used by practitioners, two indicators of success set out in the *STEM Education Implementation Plan 2017-2019* are particularly relevant.

Indicator of Success

Use of evidence by schools to support STEM education[11]

All schools to incorporate STEM within their whole-school planning activities[12]

At primary level, 70% of schools visited were found to have a whole-school planning or school self-evaluation (SSE) process that was impacting positively on STEM provision in the school. In 50% of post-primary schools visited, the impact of whole-school planning or SSE on provision for STEM was found to be satisfactory or better. These findings indicate that at both levels there is scope in a significant number of schools to strengthen whole-school approaches to STEM through improved planning or SSE processes.

Figure 12: Impact of Whole School Planning / SSE on STEM education
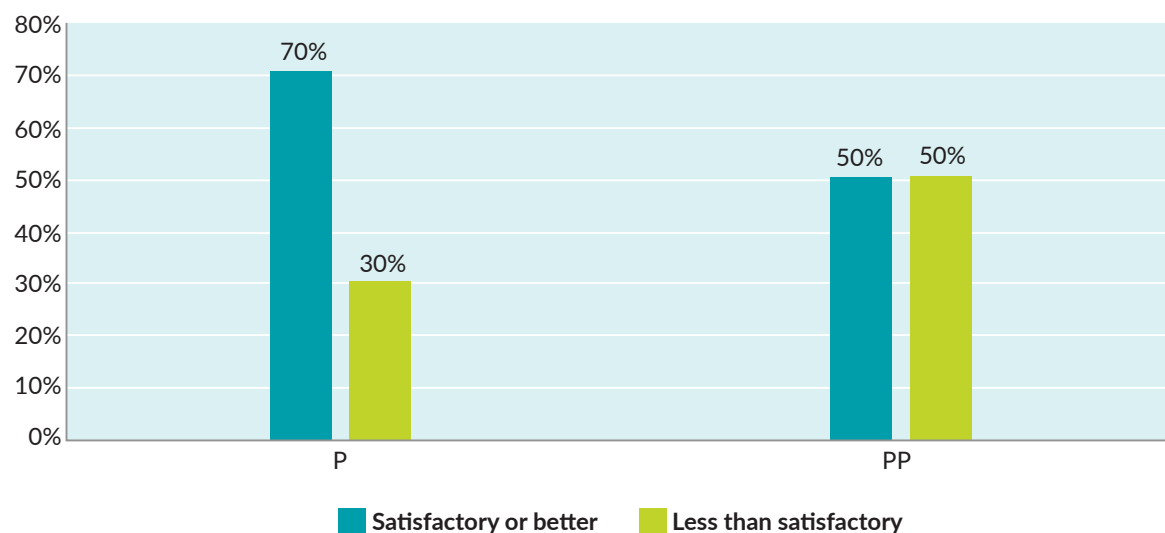
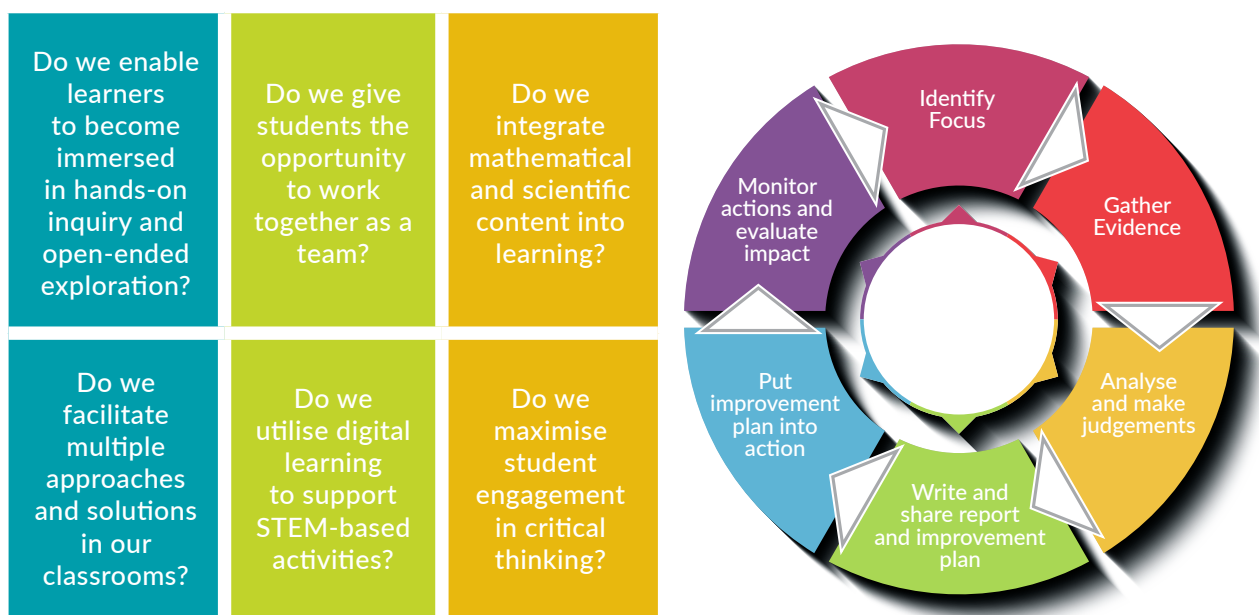11 STEM Education Implementation Plan 2017-2019 p. 4

12 STEM Education Implementation Plan 2017-2019 p. 4

4.4 STEM and SSE

Formally introduced into the Irish school system in 2012 as a collaborative, reflective process of internal school review, SSE is primarily about schools taking ownership of their own development and improvement. STEM education is an area that schools could, if they decide to, focus on and incorporate within their SSE process. Until now, schools have been using SSE to support their literacy and numeracy development in addition to a number of self-selected areas of focus in teaching and learning. SSE has also been used by schools to embed other national initiatives such as the Primary Language Curriculum at primary level or the embedding of the Framework for Junior Cycle at post-primary level.

In using the SSE process to look at and improve STEM provision, a school could pose questions for itself such as:

Figure 13: STEM and School Self Evaluation – possible questions

Do we enable learners to become immersed in hands-on inquiry and open-ended exploration?	Do we give students the opportunity to work together as a team?	Do we integrate mathematical and scientific content into learning?
Do we facilitate multiple approaches and solutions in our classrooms?	Do we utilise digital learning to support STEM-based activities?	Do we maximise student engagement in critical thinking?

These questions and the additional questions listed above (*Figure 11*) would help the school to focus on different aspects of STEM education that could be developed at classroom level and implemented across a school's curriculum.

A challenge for schools in applying the SSE process to STEM is to identify a common thread which has relevance across all curricular areas and can be implemented accordingly, on a school-wide basis. One such thread could involve the cross-curricular development of critical thinking skills. In a broad sense, critical thinking requires students to use their ability to reason. It is about being an active learner rather than a passive recipient of information. Critical thinkers rigorously question ideas and assumptions rather than accepting them at face value; these skills are essential to learners' capacities to create, innovate and solve STEM-based problems.

5 How effectively are other national STEM goals being realised?

Inspectors who were involved in the project in all three sectors captured setting/school-level data and session/lesson level data. The areas of enquiry upon which each inspector focused during their inspection visits were aligned with a number of the indicators of success outlined in the *STEM Education Implementation Plan*. This section of the report focuses on three key indicators of success outlined in the *STEM Education Implementation Plan*:

- STEM education - Performance

- STEM education - Links and Partnerships

- STEM education – Utilising Digital Technologies

5.1 STEM education – Performance

Indicator of Success
All learners will have improved performance in STEM education[13]

Outcomes of the *Trends in Mathematics and Science Study (TIMSS)* and the *Programme for International Student Assessment (PISA)* provided some benchmarks against which to gauge our STEM education outcomes. The TIMSS 2015 study stated that at fourth class in primary level, Irish students ranked 2nd in Mathematics out of the 22 participating European Union (EU) member states/territories and 9th out of all 49 countries participating. Irish students ranked 10th in Science out of the 22 EU participating member states/territories and 19th out of all 47 countries.

At post-primary level, second-year students ranked 1st in Mathematics out of the 8 EU participating member states/territories and 9th out of all 39 participating countries. In Science, Irish students ranked 3rd out of the 8 EU participating member states/territories and 10th out of all 39 participating countries.

Results of TIMSS 2019 are due in December 2020. These results will provide interesting supplementary information in relation to our achievement levels compared with students in other jurisdictions and will provide another key benchmark in relation to our overall STEM education progress.

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13 STEM Education Implementation Plan 2017-2019 p4

PISA 2015 indicated that in Science, Irish post-primary students were ranked 6th among EU member states/territories and 19th out of all countries participating in PISA. In Mathematics, Irish post-primary students were ranked 9th among EU member states/territories and 18th out of all countries participating in PISA.

PISA 2018

Results released on December 3 December 2019 continue to provide strong indications that Irish post-primary students are well placed among their counterparts in other OECD countries and in relation to students in all countries participating in the PISA assessments.

In Mathematics the overall mean score of students in Ireland in 2018 was 499.6. This was significantly higher than the OECD average score of 489.3. Ireland's ranking is 16th out of 37 OECD countries and 21st out of the total of 78 participating countries/economies.

PISA 2018 results in Ireland were close to our historic average in mathematics. While the overall trajectory of mathematics performance in the PISA assessments can be described as U-shaped, this is entirely the result of the PISA 2009 results, which were significantly below the historic average. Mean performance in all other years was close to that observed in PISA 2018.

In Science, Irish students achieved a mean score of 496.1 in science literacy, which is significantly above the OECD average (488.7) and the mean score of their peers in the EU (484.0). Ireland also ranked 17th out of the 37 OECD countries and 22nd of all 78 participating countries/economies. However, the overall trend was negative; in particular, the more recent trend (since 2012) and the trend amongst the highest performing students was markedly negative. Between 2006 and 2018, the proportion of students who scored at Level 5 or 6 on the PISA scale (top-performing students) decreased by 3.6 percentage points, and the 90th percentile of the performance distribution moved down on the PISA scale by about 5 score points per 3-year period.

The decline in Science may be partly explained by the changes in the PISA test in 2015 and 2018. Computer-based testing was introduced for the first time in 2015 and this allowed the use of test items in which students had to demonstrate the ability to apply scientific investigative skills (involving a number of variables) in experiments which were completed virtually. In 2018, the proportion of such items was increased in the PISA Science test, reflecting a growing emphasis on measuring students' ability to apply scientific skills, rather than on their knowledge of scientific facts. The ability to apply such skills is emphasised to a much greater extent in the revised Junior Cycle specification, but only 2% of the students taking the PISA 2018 test experienced the revised Junior Cycle specifications. The next round of PISA, due to take place in 2022, will provide a better estimation of the extent to which the Junior Cycle changes in Science are being effective.

The *STEM Education Policy Statement 2017-2026* and *Implementation Plan 2017-2019* commits to identifying key challenges, and opportunities to promote the uptake of STEM subjects at post-primary level. The initial focus is on how to increase the participation of females in STEM Education at early years, primary and post-primary schools. The STEM CPD Support Framework[14] aims to support the cross-sectoral design and delivery of CPD in STEM.

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14 https://www.education.ie/en/The-Education-System/STEM-Education-Policy/stem-cpd-support-framework.pdf

5.2 STEM Education - Links and Partnerships

Indicator of Success
Robust and sustainable partnerships in place between schools, business and industry, public sector bodies, research organisations, further and higher-level institutions, and the wider STEM community[14]

The impact of STEM initiatives and/or partnerships on school culture in the primary and post-primary school context was particularly positive with a number of schools exhibiting strong links with local industries and educational institutions. Such links helped to create a culture of STEM education at school level. In the primary context, there was evidence that such links impacted positively on teaching and learning experiences for pupils. In early learning and care settings, satisfactory or better STEM initiatives/partnerships were less evident. To support the creation and identification of links and partnerships, the Department of Education has developed guidelines and an accompanying online toolkit to provide the basis for both primary and post-primary schools and business/industry to form quality, inclusive and relevant educational links which are aimed at improving the STEM/Digital learning experience and securing enhanced outcomes for all learner.[16]

Figure 14: School/Setting-wide Links and Partnerships
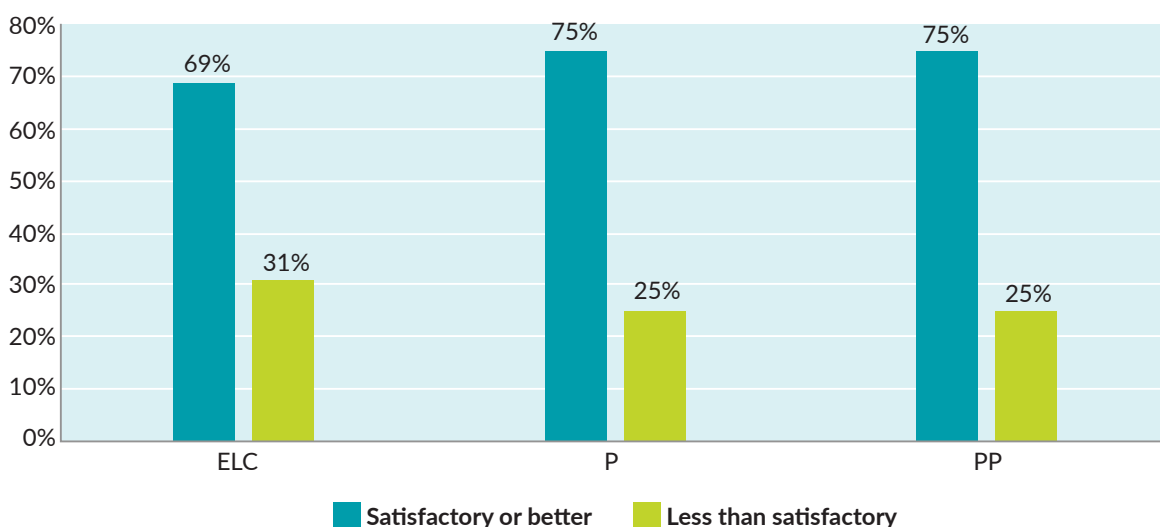
There seemed to be a contradiction of sorts when the impact of links and partnerships was explored during lesson observations. At post-primary level, just under 60% of lessons observed were deemed to have been impacted positively through local or national STEM partnerships. In comparison, 75% of the same schools were deemed to have benefitted in a satisfactory or

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15 *STEM Education Implementation Plan 2017-2019* p. 4

16 https://www.education.ie/en/The-Education-System/STEM-Education-Policy/guidelines-for-stem-school-business_industry-partnerships.pdf

better way at a whole-school level from local or national STEM partnerships. This suggests that there may well be further work to be done in order to encourage teachers to ensure that STEM education becomes an everyday experience for their students. There may also be a need to ensure that such links are consistent with the curricular requirements of teachers and students in order to maximise students' exposure to meaningful and worthwhile STEM learning experiences.

Figure 15: PP Impact of Links and Partnerships / Whole School and Lesson Comparison
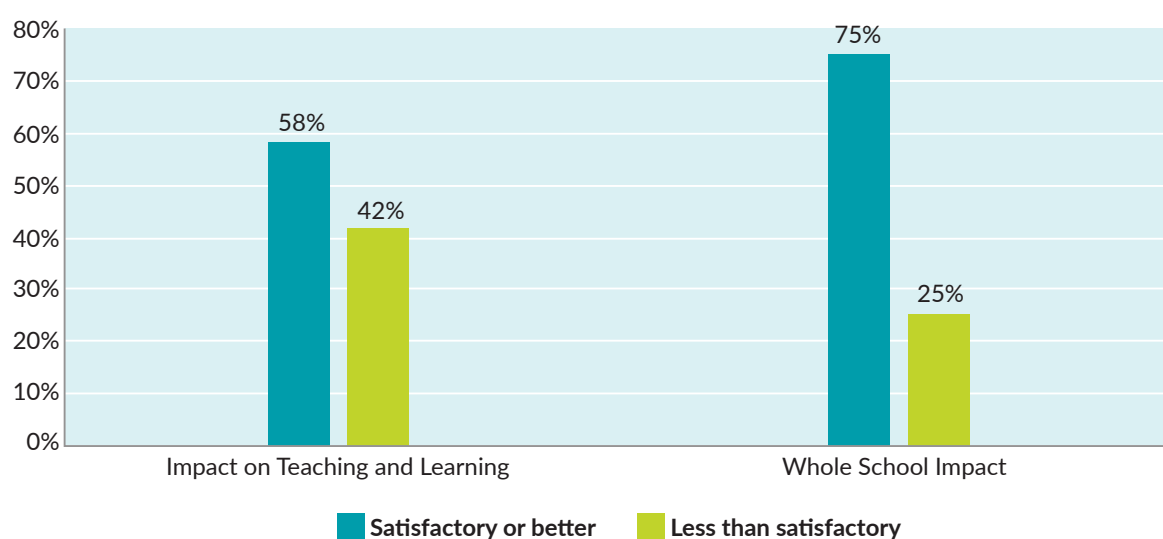
Of the twenty-nine early learning and care settings visited, none were aware of the *STEM Education Implementation Plan*. However in the early learning and care context it should be acknowledged that the communication of STEM education initiatives to the early learning and care sector has been relatively inconsistent. An online search of available early learning and care courses led to the identification of just one CPD course directly related to the *STEM Education Implementation Plan*, provided by the National College of Ireland (NCI). The goal of this innovative course was to bring early learning and care and primary educators together to experience and discuss STEM activities and to learn how to authentically incorporate STEM approaches into their practice. At the early learning and care level, initiatives like this are required to bolster effective early learning and care STEM pedagogy.

Spotlight 7 identifies how schools and pre-schools can co-operate and collaborate to improve the STEM education experiences of learners. This exemplar shows how resources and know-how can be pooled in order to maximise teaching and learning capacities in the area.

STEM Learning Spotlight 7

One primary school extended its links and partnerships across the school's community to include two other local primary schools, the feeder pre-school for all three primary schools and one local post-primary school. In doing so, they developed a number of STEM themes collaboratively including Space, Water, Buildings and Transport. STEM and the Arts were actively promoted in the schools and pre-school. There was a cross-curricular approach to teaching topics with a particular focus on STEM subjects. This involved staff and practitioners from all of the schools and settings planning strategically. The planning sessions were located in each of the schools on a rotational basis. Continuing professional development was accessed, if possible, as a cluster, to support high-quality teaching and enhance collective practice. Practitioners at all three levels shared STEM resources and communicated regularly. The learners and practitioners visited one another's schools and settings and shared their learning. Members of the group who had particular expertise or useful links in STEM in the world outside shared their knowledge to enhance STEM learning and teaching. There was an increased sharing of professional ideas, approaches and resources. In addition, regular links with the local Education Centre and the support services were maintained. The boards of management of the primary and post-primary schools provided a very broad range of co-curricular and extra-curricular STEM learning opportunities.

The group's vision was to guide their learners along new pathways of discovery through play and experimentation, discussion and questioning, gathering and sourcing information, trial and error, evaluation and assessment. These approaches helped to create an environment conducive to high-quality STEM education.

5.3 STEM education – Utilising Digital Technologies

At system level, significant work in STEM education is underway in areas such as curriculum and assessment reform, teacher professional development and the embedding of digital technologies in all classroom activities.

The *STEM Education Policy Statement* commits to ensuring that "*Teachers and early learning and care practitioners will have engaged with professional learning opportunities and will embed STEM into their teaching practice to include the use of digital technologies*". As part the Inspectorate's review of the implementation of the Department's Digital Learning Framework, an additional thirty-six STEM lessons were observed in nine further post-primary schools. In just over half (53%) of those lessons, digital technologies were incorporated into the lesson to enhance students' learning experiences. In the lessons where digital technologies were not incorporated into students' experiences, inspectors found that the use of digital technologies would have

enhanced learners' experiences overall in 63% of those lessons. This small sample indicates that there is still scope for development with regard to the greater incorporation of digital technologies into STEM teaching and learning.

Where effective use of ICT in STEM lessons was observed, there was generally good integration of STEM subjects supported by effective planning.

STEM Learning Spotlight 8

A primary school used the Digital Strategy purposefully to support STEM learning opportunities for pupils in a variety of ways. This school-wide approach included the pupils using ICT to create audio-visual recordings and to edit these recordings using software in order to share their learning with their peers. Some pupils used these skills to demonstrate their STEM project work, particularly in their engagement with the *Reel Life Science* project. Another example of the school's initiatives that have benefitted pupils' access to STEM education is the creation of a Science, Technology, Engineering, Art and Mathematics (STEAM) room. This facility enabled pupils to pursue their STEM interests within a broader context that incorporated their learning in the Visual Arts, creative design and problem solving. This environment supported the learners to complete their project tasks, some of which incorporated the use of robotics and computer programming. The staff in this school also demonstrated high levels of confidence and competence in using digital resources to support their teaching.

6 Key Findings and Recommendations

The findings of this report suggest that while both early learning and care settings and schools are now primed for greater engagement with STEM education generally, there are a number of key areas where the *STEM Education Policy Statement 2017-2026* and the *STEM Education Implementation Plan 2017-2019* have yet to make the desired impact in schools and settings. It is also clear that many primary and post-primary schools have taken initial steps, with some making very good progress and forging new pathways that maximise their learners' STEM education experiences and outcomes. The spotlights throughout this report also indicate that there is good evidence of effective STEM learning and of the efforts that some schools have made to achieve the national goals as set out in the *STEM Education Policy Statement 2017-2026*.

Need to further embed the national STEM education agenda in our schools and settings

While the many positive findings provide a most welcome backdrop to this report, one of the areas that requires ongoing monitoring is the area of raising awareness of the national STEM education agenda. Whilst it is recognised that many of the schools that engaged in this review were very aware of the importance of STEM education in general, there still remains scope for development in linking the goals of the *STEM Education Policy Statement 2017-2026* and the *STEM Education Implementation Plan 2017-2019* with a coherent and possibly nationally accredited school-based programme. The development of such a programme, with clear indicators linked back to the policy statement and implementation plan, would support schools in planning their engagement with STEM education and also help to ensure their alignment with national STEM education priorities. A national programme would not only provide structure and goals for schools and settings, but also provide recognition of their achievements in the area of STEM education.

Similarly in the ELC sector, further embedding policy and reinforcing the supports available to the sector would also significantly support and facilitate ELC settings' engagement in the national STEM education agenda. This would help to ensure that our youngest learners are given the best possible start on their STEM education journey. With this in mind, it is important to state that progress at the early learning and care level is less developed than that of the primary and post-primary sectors and further policy initiatives, supports and actions are necessary to ensure that practitioners and early learning and care settings are fully supported to engage with the national STEM agenda. This engagement should also be fully aligned with and focussed on the realisation of national STEM education goals.

Further work is required to ensure gender equity in STEM education

Another area that requires attention is gender inequality in STEM education. While it is recognised that good progress has been made in some areas, there is still significant scope for improvement. Gender parity is unfortunately still illusive, particularly in the context of uptake of technology-based STEM subjects at post-primary level. This issue is multi-faceted and, to address it, a creative and wide-ranging solution is necessary. Issues around gender stereotyping, curriculum accessibility and resourcing are all contributory factors to Ireland's high gender differential between male and female STEM graduates.

There is scope to further integrate STEM education curriculums in the primary and post-primary sectors

The finding that there was a high level of participation rates in STEM activities and STEM subjects in general, is most welcome. The high level of participation rates in STEM activities in the ELC is particularly notable as the session observations in ELC settings occurred in generic learning contexts that were not focused primarily on STEM. It is heartening that many of our youngest learners are exposed to STEM education not only in what they learn, but more importantly how they learn. This approach to STEM education methodology is certainly an area that could be further embedded at primary and post-primary levels where the compartmentalisation of subjects is more prevalent. Examples of good practice like the one outlined in *STEM Learning Spotlight 6* provide us with tangible indications of how primary and post-primary schools can organise and schedule classes and teachers to maximise learners' integrated experiences of STEM education. This presents a challenge for school leaders in relation to finding creative solutions to scheduling classes and developing thematic and cross-curricular approaches to curriculum delivery.

The development of creative environments that facilitate the incorporation of STEM education methodologies is essential

The integration of design and make skills into STEM education experiences actively promotes the fostering and development of creative critical thinking skills. To this end, inspectors noted many positive examples of practice in classrooms and learning settings where STEM education was embedded and formed part of the learners' everyday experiences. Where practice was very good, STEM learning opportunities and experiences were integrated seamlessly across a range of curriculum areas. In such cases, learners engaged in meaningful activities that developed their sense of curiosity, their problem-solving skills, their teamwork and ability to adopt multiple approaches to achieve non-prescribed solutions. Schools and settings wishing to strengthen their current STEM education programmes should certainly focus on how they can enhance teaching and learning methodologies potentially by asking themselves questions like:

- Are lessons supportive of "Design Thinking" approaches?

- Are multiple approaches and solutions encouraged?

- Is digital learning used to support STEM-based activities?

- Are links with local STEM industries and research facilities embedded?

In order to develop practice further, the creation of teaching and learning environments that will facilitate the incorporation of STEM education methodologies is essential. It was noted that in examples of good practice observed, many teachers and practitioners created atmospheres that were conducive to multiple and alternative solutions and enquiry-based methods that enabled engagement with an engineering design process of some type. It is imperative that these approaches become more widespread and that they are incorporated into learners' experiences to complement and support existing and more traditional approaches. To promote greater application of STEM-based transferrable skills, the fostering of relevant links and partnerships should also be forged where possible.

As schools engage with school self-evaluation, opportunities to foster the potential of STEM education should be considered and incorporated where practicable into their teaching and learning areas of focus

To help schools that would like to focus on aspects of teaching and learning that lend themselves to STEM education, additional support would be beneficial, particularly through the provision of resources and advice that could be used at school level to aid reflection and review within the Department's existing SSE structures. The potential benefits of STEM education should be considered and incorporated where practicable into day-to-day teaching and learning. This process should be structured within the school self-evaluation process where possible. By posing questions, challenging their approaches and by self-evaluating their STEM education practices, schools and settings will be well placed to recognise their strengths and proactively address any identified areas for development. The *STEM Education Implementation Plan 2017-2019* outlines key indicators of success that could inform this process at school and setting level.

Innovative approaches to supporting and incentivising schools and settings in terms of STEM should be identified. In particular, there is a need to ensure that schools have appropriate STEM learning spaces and access to necessary STEM resources

Parallel to the development of pedagogy, there is also a need to support schools and settings in the reimagining of creative spaces where STEM education methodologies and STEM-based learning can flourish. It is incumbent on those responsible for planning associated infrastructural developments to progress these changes in line with the necessary evolution of pedagogy. Creative spaces should be identified in all schools and settings and, where necessary, resourced accordingly. Whilst it is recognised that resourcing needs will understandably vary and will impact learners in different ways depending upon their age and stage of development, a key consideration should be that learners' creativity should be fostered where possible and not be negatively impacted upon due to the availability or otherwise of STEM-learning resources and facilities.

Schools and early learning and care settings should continue to work to make STEM education an integrated feature of teaching, learning and assessment

It is also incumbent on schools and early learning and care settings to continue to work towards ensuring that STEM education is an integrated feature of learners' experiences of teaching, learning and assessment. Leaders in the sector should promote the integration of meaningful STEM education approaches as inherent components of everyday practice. This might present

challenges for many post-primary schools and, to a lesser extent, primary schools where the propensity to teach STEM subjects in isolation may exist. This propensity should be challenged where possible in order to create a more integrated approach to learning that encompasses the associated skill sets of the STEM disciplines.

CPD providers and ITE courses, and early learning and care practitioner courses should ensure that effective STEM education methodologies are incorporated into teacher/practitioner training courses and CPD

To help achieve these goals it is also essential that teachers and practitioners are provided with the necessary advice, training and CPD. ITE courses and providers of education and training for ELC practitioners should review their programmes to ensure that they reflect and incorporate the associated pedagogies that are applicable to the STEM education experience. Without the further development and reinforcement of the importance of these areas, a skills deficit may well materialise. This is particularly relevant for practitioners working in the ELC sector. At primary and post-primary levels, significant resources have been developed to provide advice and supports for teachers of STEM and these resources are bearing fruit, resulting in the development of highly developed resources and supports for teachers. Future iterations of Cosán, the Framework for Teachers' Learning could also reflect STEM as a key learning area thereby further supporting teachers' professional development journeys and embedding STEM CPD across the sectors. Teachers' lifelong learning in the area of STEM education would certainly benefit from the multi-dimensional approach espoused in Cosán where teachers' learning may be formal or informal, personal or professional, collaborative or individual, and school-based or external, and often a combination of these dimensions.

There is a need to create activities that support effective STEM education and positive STEM experiences for learners

But how can we ensure that learners across the three sectors are provided with as many opportunities to engage in STEM education as possible? To achieve this it is imperative that creative activities that foster and support effective STEM education are identified. The STEM Learning Spotlights throughout this report demonstrate that from early years learning to senior cycle post-primary education, planning, creativity and an adherence to the key principles that underpin STEM education are essential components of successful STEM education experiences. Where these activities were best developed, learners were enabled to engage in tasks that imbued discovery, inquiry and exploration, all approaches that develop a STEM mind-set. The challenge for educators is to ensure that these tendencies, all of which are naturally occurring and abundant in children and young people, are given the opportunity to develop and to grow. To achieve this, we will need to be cognisant of other factors that may negatively impact learners' experiences of STEM education methodologies. We will also need to resist the temptation to focus on content at the expense of skill development, particularly in relation to the models of assessment that we choose for our children and young people. Embedding Aistear, the Primary School Curriculum (1999), the Framework for Junior Cycle (2015) and future reviews at senior cycle post-primary will support this and facilitate a coherent approach across sectors that improves learners' experiences and outcomes overall.

Additional policy guidance in the area of effective STEM education approaches in the early learning and care sectors should be developed

The challenge for the ELC sector is to ensure that it can engage with STEM education even though to date, the level of supports available to the sector does not correspond with that of the primary and post-primary sectors. Policy guidance and engagement with relevant partners and stakeholders in the area of effective STEM education approaches in the ELC sector is necessary in order to put the strategies in place to realise the goals set out in the *STEM Education Policy Statement*.

Conclusion

The importance and relevance of STEM education was abundantly clear during the course of the COVID-19 pandemic when the initial shortage of personal protective equipment (PPE) and specifically face shields resonated with many learners in Irish schools. Some learners utilised the skills and tools available to them to rapidly prototype and produce the required PPE in their schools to supplement the national shortfall in supply. This design and make approach and real-world application of critical thinking skills, enabled our young learners to contribute in a meaningful way to the fight against the virus. This example demonstrates how an integrated approach to science, technology, engineering and mathematics can have a positive impact on our lives and also how these disciplines can co-exist and interact effectively to realise a design solution for the good of society overall.

As we continue to evolve and to develop it is certain that many more challenges will face us, and if we can equip our young learners with the STEM tools that will enable them to tackle these challenges in a solution-focused manner then our future challenges may well be overcome through the application of innovation and creativity grounded in STEM education.

Glossary

Glossary Term	Definition
AR	Augmented Reality
CPD	Continuing Professional Development
CSO	Central Statistics Office
DCG	Design and Communication Graphics
EU	European Union
EY	Early Years
EYEI	Early Years Education Inspection
ICT	Information and Communication Technology
IoT	Internet of Things
ITE	Initial Teacher Education
JCT	Junior Cycle for Teachers
NCI	National College of Ireland
OECD	Organisation for Economic Co-operation and Development
PDST	Professional Development Service for Teachers
PISA	Programme for International Student Assessment
SSE	School Self-Evaluation
STEAM	Science, Technology, Engineering, Art & Mathematics
STEM	Science, Technology, Engineering & Mathematics
TG	Technical Graphics
TIMSS	Trends in International Mathematics and Science Study
TY	Transition Year

Acknowledgements

The following schools' STEM practices are exemplified in the Spotlights outlined throughout this report. We would like to thank these schools, their teachers and their students for their engagement and support in providing examples of good practice.

Spotlight 1	Vicarstown NS, Vicarstown, County Cork
Spotlight 2	Scoil Íosagáin, St. Mary's Road, Buncrana, Co. Donegal
Spotlight 3	Coláiste Bhaile Chláir, Lakeview, Baile Chláir, Co na Gaillimhe
Spotlight 4	Holy Family Secondary School, Newbridge, County Kildare
Spotlight 5	Scoil Naomh Fionán, Whitecastle, Quigleys Point, County Donegal
Spotlight 6	Carrigtwohill Community College, Unit 2A Fota Business Park, Carrigtwohill, County Cork
Spotlight 7	St. Mary's NS, Ballinagare, Castlerea, Co. Roscommon
Spotlight 8	St. Hugh's NS, Dowra, via Carrick-on-Shannon, County Leitrim

An Roinn Oideachais
Department of Education

This report presents the findings of an Inspectorate evaluation of the implementation of the first phase of the *STEM Education Policy Statement 2017-2026* in a sample of primary and post-primary schools and early learning and care settings during the period January 2019 to December 2019.

The report is also designed to provide a benchmark for the education system and policy makers more broadly in relation to how STEM education policy is being implemented at school and early learning and care setting level and to inform actions that may need to be taken to ensure that national STEM education objectives can be achieved.

The report is also intended to be a resource for education practitioners at early learning and care, primary and post-primary levels through providing illustrations of effective STEM education as observed in the course of the evaluation project.

An Roinn Oideachais
agus Scileanna
Department of
Education and Skills