# Background Paper and Brief for the Review of Junior Cycle Technology Subjects

An Chomhairle Náisiúnta Curaclaim agus Measúnachta
National Council for Curriculum and Assessment

September 2017

# List of Tables and Figures

# Contents

# 1. Introduction

The technology subjects will be introduced in 2019 as part of phase five of the *Framework for Junior Cycle* implementation. The curriculum and assessment specification for these subjects will be published a year earlier in the autumn of 2018. This paper provides a background for the development of the specifications for junior cycle technology subjects. The background paper includes an overview of historical milestones and the growth of the subjects in the Irish education system, international practices of the subjects and at the role of technology education in the 21st century.

For the purpose of this paper and process, where reference is made to the technology subjects, it includes the subjects

- Materials technology (Wood)
- Metalwork
- Technical Graphics
- Technology

This paper also outlines current research in the teaching of technology subjects nationally and internationally, and the key emerging themes from the research such as the unequal gender uptake and the innovative practices or new technologies that will have an impact on the future development of the subjects. Finally, this paper sets out the brief for the development of the specification.

# 2. Background

## 2.1. Evolution of technology education (1926 – 2017)

The evolution of the technology subjects as they now appear in the Junior Certificate curriculum (Materials Technology (Wood), Metalwork, Technical Graphics and Technology) is inextricably bound up with the development of vocational education in Ireland. The first attempt to provide education in the technology subjects in Ireland happened in 1899 as a result of the condemnation of the lack of vocational and technical education in the *Report of the Intermediate Education Commission* (1899). This resulted in the establishment of a Department of Agriculture and Technical Instruction in 1900 and this Department established a series of technical schools around the country to provide specialised education based on local needs (Mulcahy, 1981). The Technical schools provided the only form of vocational education in this country until the new state in 1924 sought to reform the education system. Vocational education was originally regarded as being concerned with the development of technical knowledge and practical skills to fulfil the industrial and agricultural needs of the new state. This paper will discuss some of the pivotal changes in the provision of vocational education from 1926 to the present day and their impact on the technology subjects.

1926 – 1947

In 1926, the Department of Education set up a *Commission to Enquire into Technical Education* (Coolahan, 1981, p. 94). This commission included two representatives from Switzerland and Sweden selected due to their expert knowledge of the vocational education sector and the similarity of their countries' economic structures to Ireland's at the time. The commission presented its report on the 5th of October 1927 and it contained a number of key recommendations. The most influential recommendation was that two types of school, continuation and technical, should be established. The continuation school was intended to provide an intermediate stage for pupils between the ages of 14 and 16 years before they followed a more specialised education in the Technical schools, (Clarke, 2012). The Vocational Education Act (1930) established 38 Vocational Education Committees (VECs) to oversee these schools. According to the Act, these schools would provide continuation education which meant 'education to continue and supplement education provided in elementary schools and includes general and practical training in preparation for employment in trades, manufacturing, agriculture, commerce and other industrial pursuits' (Hyland and Milne, 1992, p.214). The new state also introduced an Apprenticeship Act in 1931 to further regulate the development of vocational skills and training. This act provided for apprentices receiving obligatory technical education through the VECs, (O'Mahony, 2014).

As part of the assurances given by the Minister for Education J.M. O'Sullivan to the secondary school sector, the curriculum in these schools would not overlap with that provided in secondary schools (Coolahan, 1981). As an alternative to the academic secondary tradition, continuation education in the vocational schools gave greater attention to subjects of a technical or practical nature and allowed for variation in content to reflect the needs of the urban or rural community. From the beginning the courses offered were gender specific. Boys were offered courses such as a junior technical course, a junior commercial course and a junior rural course. Girls were offered a junior domestic science course, a junior commercial course or a junior rural course (Coolahan, 1981). This gendered provision from the outset has had far reaching consequences on the gender profile of students taking these subjects.

The curriculum followed in the vocational schools varied greatly. As outlined in the *Report of the Department of Education 1931 to 1932*, 'broad principles were laid down by the Department for the conduct of courses but no attempt was made to prescribe the syllabuses of instruction to be followed (DES, 1932, p. 46). Memo V. 40 written in 1942, identified and outlined courses for the vocational schools according to the local needs of a county and the junior technical course for boys included the subject Manual Instruction (wood and metal), (Mulcahy, 1981, p. 17). The practical, skills-based focus of the courses reflected the employment needs of their local community and the expected progression route of their pupils to trade or industry.

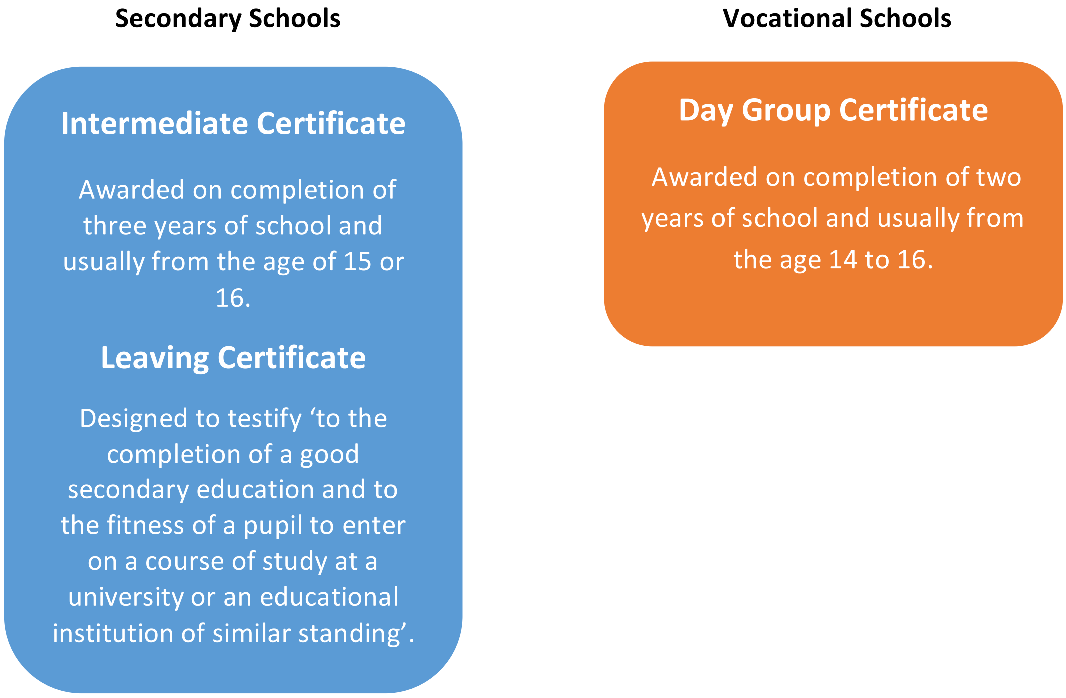
It is worth noting that, in 1927, one of the first educational initiatives of the new state was 'the establishment of a specific training programme to train teachers of both Metalwork and Woodwork' which allowed for the full implementation of the Vocational Education Act.

The state was now providing two forms of post primary education, secondary and vocational. The curriculum in secondary schools was mainly academic and 'prepared students for third-level education and white-collar occupations' (Lewis & Kellaghan, 1987, p. 7). Some secondary schools did offer some subjects that at the time were considered to have a vocational or practical focus such as mechanical drawing and woodwork, but these subjects were of limited value for matriculation purposes. The students of these schools had two state qualifications available to them, the Intermediate Certificate and the Leaving Certificate.

However, the students in vocational schools did not have access to the Intermediate or Leaving Certificate examinations and had no means of certification until the introduction of the Day Group Certificate in 1947 following representations to the Department from the Irish Technical Education Association (Mulcahy, 1981). Students preparing for the Day Group Certificate examinations studied Irish, English, civics and subjects from at least one of the five groups categorised as Commerce (General), Commerce (Secretarial), Domestic Science, Manual Training (woodwork, metalwork, mechanical drawing and art) and Rural Science. Post primary education referred to very limited numbers of pupils. The School Attendance Act (1926) made school attendance mandatory for those between 6 and 14 years of age, the majority of whom attended primary schools or secondary-top. While discussions were held during the 1930s regarding raising the school leaving age to 15 it was abandoned as neither practicable nor desirable due to the lack of adequate facilities for post primary education in many districts (Hyland and Milne, 1992). By 1951, 4,591 students sat the Leaving Certificate examinations, 10,472 sat the Intermediate examinations and 3,243 sat the Day Group Certificate examinations (Department of Education, 1952, p. 31).

The result of this early development of the technology subjects was that as vocational schools had no access to the academic route to third level, the subjects were seen as having less educational status than those provided in secondary schools. The gendered provision of subjects created a dichotomy between the technology subjects and domestic science or commerce. The next major reform of educational provision that had an impact, not only the curriculum and subjects provided, but also the access to second level, occurred in the 1960s.

*Figure 1 - Comparison of the Intermediate Certificate and the Day Group Certificate*




<u>1960-1989</u>

In 1963, the then Minister for Education, Patrick Hillery, pointed out that technical education

> *would give the country a systematic supply of youth with a sufficient technical education to become at a later stage the technicians and higher technicians the country is, as we hope, going to need*

(OECD, 1969, p. 126)

At this time, expenditure in education was viewed as an investment and the need to address the provision of technical and scientific education was highlighted by the OECD Report *Investment in Education* (1966).

In 1966, Hillery introduced greater diversity to the post primary school curriculum by introducing a 'comprehensive curriculum'. This first step in creating a unified system of post primary education proposed that pupils from vocational schools could now sit the Intermediate Certificate examinations and that the more practical, vocational subjects hitherto only available in vocational schools would be made available to secondary school pupils. In order to facilitate this, common courses and examinations were introduced for the Intermediate Certificate from 1966 and for the Leaving Certificate from 1968. New subjects were also introduced; Metalwork and Woodwork were added to the subject lists for Intermediate Certificate, and Building Construction, Engineering Workshop Theory and Practice, Technical Drawing and Mechanics were introduced as Leaving Certificate subjects (Mulcahy, 1981).

This was regarded as a very significant change and it was hoped that

> *the reform would result in a widening of the range of subjects available in all second level schools and, in particular, that a greater emphasis would be placed on technical, practical and vocationally orientated subjects*

(Lewis & Kellaghan, 1987, p. 8)

*Table 1 - Numbers taking technology subjects as Day Group Certificate Examination, 1969 – 1983*

| | 1969 | 1973 | 1977 | 1983 |
|---|---|---|---|---|
| **Number taking DGCE** | 14481 | 18245 | 18136 | 19961 |
| ***Mechanical Drawing*** | 54.2% | 57.1% | 50.0% | 46.0% |
| ***Metalwork*** | 41.8% | 40.8% | 36.2% | 32.2% |
| ***Woodwork*** | 56.7% | 55.5% | 48.2% | 42.7% |

*Table 2 - Numbers taking technology subjects as Intermediate Certificate Examination, 1969 – 1983*

| | 1969 | 1973 | 1977 | 1983 |
|---|---|---|---|---|
| **Number taking ICE** | 30967 | 39171 | 48340 | 55071 |
| ***Mechanical Drawing*** | 43.3% | 34.4% | 43.0% | 56.4% |
| ***Metalwork*** | 18.7% | 20.3% | 24.3% | 26.3% |
| ***Woodwork*** | 24.5% | 30.1% | 38.5% | 40.3% |

The numbers participating in the examinations for the vocational subjects never achieved the increase projected in the initial plans for a number of reasons. In order to facilitate the provision of practical subjects in post primary schools, the Minister initiated the building of comprehensive schools in areas where there was no vocational or secondary provision. The first of these schools opened in 1966 in Shannon. In other areas, the authorities of secondary and vocational schools were asked to meet with a view to sharing both facilities and teachers, possibly leading to the amalgamation of schools. These suggestions were not met with enthusiasm. The introduction of free second-level education announced by Donogh O'Malley in 1966 meant that demand for second level places far outweighed the facilities available. By the 1970s the Department moved away from comprehensive schools to introduce new community schools to provide the necessary capacity to the system. The community schools also aimed to unify the second level provision of traditionally academic and vocational subjects but also provided links to the community so they could respond to local needs.

The other influencing factor on the uptake of the technical or practical subjects was the initial unwillingness of the universities to accept the new technical subjects introduced for matriculation purposes. This narrowed the range of subjects available to students who wished to progress to third level. The other unforeseen effect of the common courses and examinations was that the numbers taking the Day Group Certificate examinations in technical and applied subjects dropped in comparison to the take up of academic or secondary subjects. According to Mulcahy (1981, p. 44), this may be attributed to societal and parental attitudes which favoured more traditional subjects. In response to the lack of progression available at third level in the technical areas the state intervened by establishing the National Institute of Higher Education (NIHE) in Limerick in 1968, the Regional Technical Colleges in 1972 and the National Council for Educational Awards (NCEA) in 1972 to grant awards in the non-university third level sector.

Despite the increasing numbers at second level and the new schools and subjects available, the numbers taking technology subjects failed to rise as expected. The lack of progression routes to third level for technical subjects had, in some way, been addressed by the Department in the founding of NIHE and the Regional Technical Colleges.

<u>1985 – 2017</u>

The introduction of the Junior Certificate in 1989 was a significant milestone for the education sector. This new qualification would consolidate the Day Group Certificate and the Intermediate Certificate into a unified qualification and first examination would take place 1992.

As part of the new Junior Certificate qualification, a new subject, Technology, was introduced with the intent that the subject would be:

> *the achievement of human purposes through the disciplined use of materials, energy, and natural phenomena. Education in and through technology involves' appropriate resources, suitable tasks, and the interplay between the two.*

(Department of Education, 1989d, p. 2)

The subject was introduced on a phased/restricted basis over the initial years. Schools had to be approved to introduce this subject, and did so on very limited resources.

In the following years, the remaining technical subjects were reformed and introduced. Under the Junior Certificate programme, the subject Metalwork continued but Materials Technology (Wood) and Technical Graphics replaced Woodwork and Mechanical Drawing respectively.

Very few curricular advances took place within the technology subjects until 2006, when two significant events took place. A new subject support group known as T4 was established that took all the technology based subjects together at both Junior Cycle and Senior Cycle under one professional development umbrella. This service was designed to support the teachers of technology subjects and provide continuing professional development, especially for the new syllabuses that were about to be introduced at Senior Cycle. Coinciding with the launch of T4, then Minister of Education and Skills, Mary Hanafin, TD announced a number of changes to the Senior Cycle technology subjects, which would take effect from the 2007/2008 academic year:

- Technology would be offered as a Leaving Certificate subject as a progression option from Junior Certificate Technology.
- Technical Drawing would no longer be offered to students in its current form. *Design and Communication Graphics* would take its place and introduce the students to new technologies that would not only change the way students would be assessed in the subject but also change the way they would learn - 'armed with the latest technology at their fingertips students will be at the cutting edge of new technologies education' (Department of Education and Science, 2006).

The remaining two subjects would undergo a curriculum reform and change titles from

- Engineering to Engineering Technology
- Construction Studies to Architectural Technology

Revised syllabuses for these two subjects were developed but a decision was made to delay the implementation of the curriculum reform for Engineering and Construction Studies. This may have been the result of the economic downturn in the country at the time.

## 2.2. Technology subjects in Junior Cycle

**Junior Cycle Overview**

At present, there are four options at Junior Cycle for technology subjects. Across the four syllabuses the stated aims strive to foster creative problem solving and design along with developing the necessary manipulative skillset for the subject area. For example, the Materials Technology (Wood) syllabus aims to 'develop a creative approach to problem solving in the design process through designing, making and evaluating, and to promote initiative, enquiry and discrimination.' (Department of Education, 1989a, p. 4). The Metalwork syllabus aims to 'Link observation and action with ingenuity and creativity and with problem-solving and higher level responses.' (Department of Education, 1989b, p. 2). The Technology syllabus has broader aims which include 'to develop in the student the abilities to make a critical evaluation of a piece of work and to take appropriate action (Department of Education, 1989a, p. 2), while the Technical Graphics syllabus contained aims that may not have formed part of the daily teaching of the class such as the aim 'to develop basic competency in computer graphics in the context of graphical problem-solving and computer aided design' (Department of Education, 1989c, p. 5).

The following is a summary overview of these subjects, with associated assessment for examination details.

*Figure 2 - Overview of current Junior Certificate technology subjects*

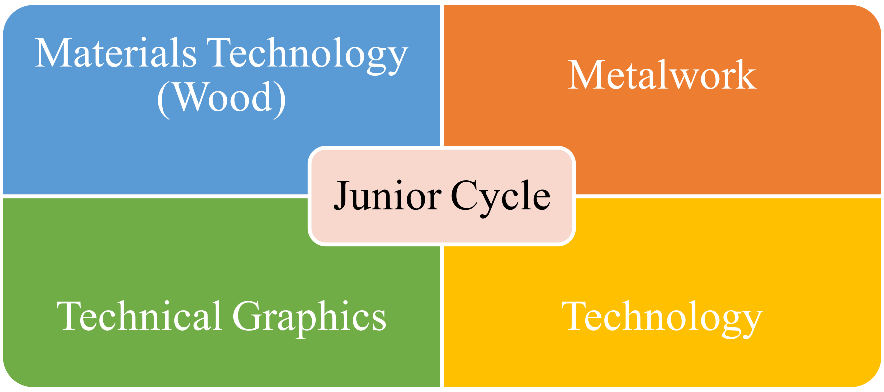


*Table 3 - Breakdown analysis of the technology subjects*

| | Materials Technology (Wood) | Metalwork | Technical Graphics | Technology | |
|---|---|---|---|---|---|
| *Offered at Higher Level* | ✔ | ✔ | ✔ | ✔ | |
| *Offered at Ordinary Level* | ✔ | ✔ | ✔ | ✔ | |
| *Project Weighting* | 66.6% | 75% | 0% | O/L 60% | H/L 50% |
| *Project Breakdown* | **Ordinary Level** Project = 49.95% Portfolio = 16.65%<br>**Higher Level** Project = 43.29% Portfolio = 23.31% | **Ordinary Level** Project = 75%<br>**Higher Level** Project = 37.5% Day Exam = 37.5% | | **Ordinary Level** Project = 36% Portfolio = 24%<br>**Higher Level** Project = 20% Portfolio = 30% | |
| *Written Exam Weighting* | 33.3% | 25% | 100% | O/L 40% | H/L 50% |
| *Written Exam Breakdown* | **Ordinary Level** 2 Hours<br>**Higher Level** 2 Hours | **Ordinary Level** 1.5 Hours<br>**Higher Level** 2 Hours | **Ordinary Level** 2.5 Hours<br>**Higher Level** 3 Hours | **Ordinary Level** 2 Hours<br>**Higher Level** 2 Hours | |

## Key Observations

- Of note from the table above, is that while Technical Graphics is considered a practical subject, it offers no practical/project component in its assessment for certification.
- There is no parity in the breakdown in the assessment of each of the subjects, i.e. a student studying ordinary level Metalwork can achieve a maximum 75% towards their final mark by only having to produce an artefact. Yet, if that same student is studying ordinary level Materials Technology (Wood) as part of their Junior Certificate, and only manged to produce an artefact towards their final assessment, he/she can only achieve a maximum 49.95%.
- Metalwork students, at higher level, seem to be over-assessed on their craft skills with the addition of a practical day exam. However, there is no reflective process available to metalwork students to evaluate their learning such as there is in Materials Technology (Wood) and Technology through the portfolio.

- The marks awarded to the project and portfolio in Technology changes at ordinary level and higher level. A higher percentage of the marks is awarded to the project at ordinary level, yet the project receives a smaller percentage of the marks than the portfolio at higher level.
- While the four subjects fit into a technology 'suite', the aims of each of the subjects (see Appendix 1) have few similarities. The strongest similarity amongst the subjects is the reference to problem solving in each syllabus.

*Table 4 – Analyses of students sitting Materials Technology (Wood) JC examination, 2008 - 2016*

| Materials Technology (Wood) | | | |
|---|---|---|---|
| **Year** | **Total JC Candidates** | **Total Subject Candidates** | **%** |
| **2008** | 55940 | 15609 | **27.9%** |
| **2009** | 55557 | 15254 | **27.5%** |
| **2010** | 56086 | 15224 | **27.1%** |
| **2011** | 56841 | 15168 | **26.7%** |
| **2012** | 58798 | 15775 | **26.8%** |
| **2013** | 59822 | 16163 | **27.0%** |
| **2014** | 60328 | 16464 | **27.3%** |
| **2015** | 59522 | 16145 | **27.1%** |
| **2016** | 60248 | 16381 | **27.2%** |

*Table 5 - Analyses of students sitting Technical Graphics JC examination, 2008 - 2016*

| Technical Graphics | | | |
|---|---|---|---|
| **Year** | **Total JC Candidates** | **Total Subject Candidates** | **%** |
| **2008** | 55940 | 11850 | **21.2%** |
| **2009** | 55557 | 11976 | **21.6%** |
| **2010** | 56086 | 12028 | **21.4%** |
| **2011** | 56841 | 11914 | **21.0%** |
| **2012** | 58798 | 12004 | **20.4%** |
| **2013** | 59822 | 12564 | **21.0%** |
| **2014** | 60328 | 12349 | **20.5%** |
| **2015** | 59522 | 11701 | **19.7%** |
| **2016** | 60248 | 11931 | **19.8%** |

*Table 6 - Analyses of students sitting Metalwork JC examination, 2008 - 2016*

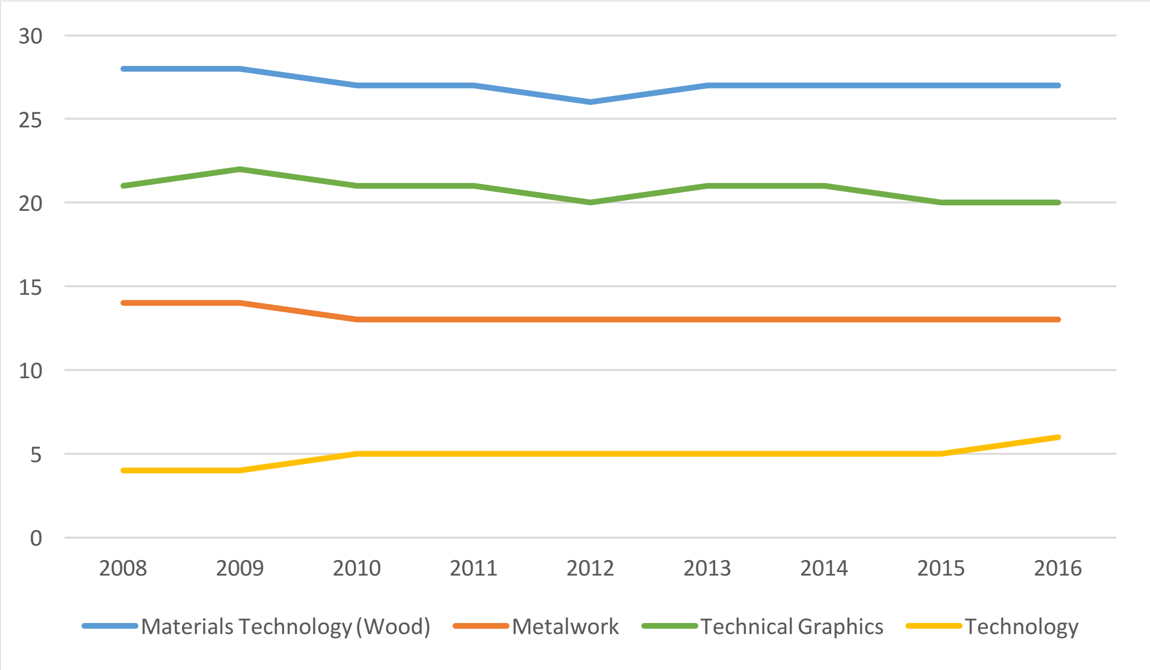
| Metalwork | | | |
|---|---|---|---|
| **Year** | **Total JC Candidates** | **Total Subject Candidates** | **%** |
| **2008** | 55940 | 7722 | **13.8%** |
| **2009** | 55557 | 7548 | **13.6%** |
| **2010** | 56086 | 7281 | **13.0%** |
| **2011** | 56841 | 7414 | **13.0%** |
| **2012** | 58798 | 7739 | **13.2%** |
| **2013** | 59822 | 7843 | **13.1%** |
| **2014** | 60328 | 7880 | **13.1%** |
| **2015** | 59522 | 7984 | **13.4%** |
| **2016** | 60248 | 7887 | **13.1%** |

*Table 7 - Analyses of students sitting Technology JC examination, 2008 - 2016*

| Technology | | | |
|---|---|---|---|
| **Year** | **Total JC Candidates** | **Total Subject Candidates** | **%** |
| **2008** | 55940 | 2334 | **4.2%** |
| **2009** | 55557 | 2470 | **4.4%** |
| **2010** | 56086 | 2664 | **4.7%** |
| **2011** | 56841 | 2788 | **4.9%** |
| **2012** | 58798 | 3026 | **5.1%** |
| **2013** | 59822 | 2957 | **4.9%** |
| **2014** | 60328 | 3223 | **5.3%** |
| **2015** | 59522 | 3258 | **5.5%** |
| **2016** | 60248 | 3576 | **5.9%** |

**Key Observations**

- With the growth of the technology sector nationally and globally, one might expect to see an increase in the uptake of the technology subjects, but from the data gathered, the numbers of students sitting the subjects for examination appear not to have increased significantly in recent years.




- Technology does make a slight increase from 4% to 6%. A contributing factor to this may be the fact that it was only in 2007 that a progression option became available in the form of Leaving Certificate Technology.
- The question arises as to whether the cost implications of facilitating these subjects have a negative impact on the decisions made to offer them in schools.

## 2.3. Gender uptake of the technology subjects at Junior Certificate

The number of males sitting the subjects continues to significantly outweigh the number of females across all the technology subjects (see Table 8).

*Table 8 - Subject uptake by gender 2008 - 2016*

| | Materials Technology (Wood) | | Metalwork | | Technical Graphics | | Technology | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Male (%)** | **Female (%)** | **Male (%)** | **Female (%)** | **Male (%)** | **Female (%)** | **Male (%)** | **Female (%)** |
| **2008** | 88 | 12 | 92 | 8 | 86 | 14 | 80 | 20 |
| **2009** | 88 | 12 | 91 | 9 | 86 | 14 | 78 | 22 |
| **2010** | 87 | 13 | 91 | 9 | 86 | 14 | 79 | 21 |
| **2011** | 87 | 13 | 91 | 9 | 87 | 13 | 80 | 20 |
| **2012** | 88 | 12 | 91 | 9 | 86 | 14 | 80 | 20 |
| **2013** | 87 | 13 | 92 | 8 | 86 | 14 | 82 | 18 |
| **2014** | 87 | 13 | 91 | 9 | 86 | 14 | 84 | 16 |
| **2015** | 85 | 15 | 90 | 10 | 85 | 15 | 81 | 19 |
| **2016** | 84 | 16 | 90 | 10 | 85 | 15 | 81 | 19 |

**Key observations**

- There is no significant increase in the female uptake of any of the four subjects in the last 9 years observed.
- Part of the perceived rationale for introducing Technology as a subject was to rectify the gender imbalance evident in the participation rates for the other technology subjects. From the figures above, it would suggest that this strategy has not been overly successful.

## 2.4. Chief Examiners' Reports

The Chief Examiners' Reports provide an analysis of the candidates' performance and standard of students' work across various subjects in the State Examinations. The following reports, specific to the junior cycle technology subjects, were reviewed as part of this background paper:

- Materials Technology (Wood) – 2002, 2006, 2009
- Metalwork – 1999, 2002, 2010
- Technical Graphics – 1999, 2002
- Technology – 1999, 2002, 2009

A number of the Chief Examiners' Reports highlighted good practices across the subjects with a project element, especially in relation to preplanning.

> *In some centres candidates prepared prototypes / models to show overall shape and size. Such preplanning of coursework is highly recommended as it saves time and mistakes later in the manufacturing process*
>
> *(State Examination Commission, 2009b, p. 9)*

> *The most successful responses made use of mock ups, or models, to test their ideas before producing the artefact; however, this was not as widespread as is desirable.*

(State Examination Commission, 2009c, p. 27)

However, part of the function of the Chief Examiner's Report is to offer suggestions as to areas of improvement within the subject. The limitations of the students' abilities in designing and reflection/evaluation of their coursework has been commented upon by the Chief Examiners across these subject areas. At present, there is a design element in the Materials Technology (Wood), Metalwork and Technology coursework. The Metalwork Chief Examiner's Report (2009) noted 'Candidates' responses to the design feature were poor in many cases… There was a lack of diversity of solutions in many cases'. A number of the Chief Examiners' reports presented a common recommendation to teachers to provide the student with frequent opportunities to engage with the design process over the three years of study. This would suggest that the design aims of the syllabuses are not being fulfilled.

In the Materials Technology (Wood) Chief Examiner's Report (2009, p.15), while it acknowledged that the 'the vast majority of coursework presented expressed the individual design ideas and design solutions', it did however observe that when it came to evaluating the projects, students struggled with the reflection/critical thinking aspect.

> *This reflection on learning is challenging and many candidates have difficulty with evaluation. Many evaluations consisted of general statements about how the coursework progressed and how they regard the finished product. Candidates are encouraged to reflect on what they have learned and to include a critical reflection of their learning journey while engaged with the coursework.*
>
> *(State Examination Commission, 2009c, p. 10)*

A common misconception students have, when approaching the evaluation stage of any project, is to limit their discussion to the positive aspects of their work. The Chief Examiner's Report (2009) for

Technology highlighted this common misconception as part of the analysis of the candidate's performance: 'Many candidates were unwilling to highlight obvious defects and, in many cases, a fault or omission in the product was not identified' (State Examination Commission, 2009c, p. 26). This implies that the aim 'to develop in the student the abilities to make a critical evaluation of a piece of work and to take appropriate action' (Department of Education, 1989, p. 2) is not being fulfilled.

## 2.5. Section summary

The Vocational Education Act (1930) set out a series of events that revolutionised vocational education and the provision of practical subjects in Irish schools.

The evolution from the Day Group Certificate and Intermediate Certificate to the Junior Certificate has not changed the craft-focus of the subjects; subjects whose origins emerged largely from a desire to orientate students towards a craft or workforce progression. The subjects have very significantly shaped the technology education of today's students whose educational needs are quite different from those of previous generations.

Despite the inclusion of technology as a subject to address the gender imbalance, the uptake of all four subjects is made up predominantly of boys. This raises questions regarding the traditional gendered provision of the subjects and how this has impacted the long-term uptake of the technology subjects. The perceived dichotomy between the technology subjects and other subjects has continuing implications for schools and how the subjects are offered to students.

Despite the stated aims of the syllabuses the absence of a significant focus on the design process within the learning, teaching, and assessment related to the existing subjects is notable and is often remarked upon in the Chief Examiners' Reports.

Despite rapid and substantial changes in all aspects of technology in the past decade, since the introduction of Design and Communication Graphics and Technology, there have been few if any major curricular advances or changes made to the technology subjects at junior cycle or senior cycle.

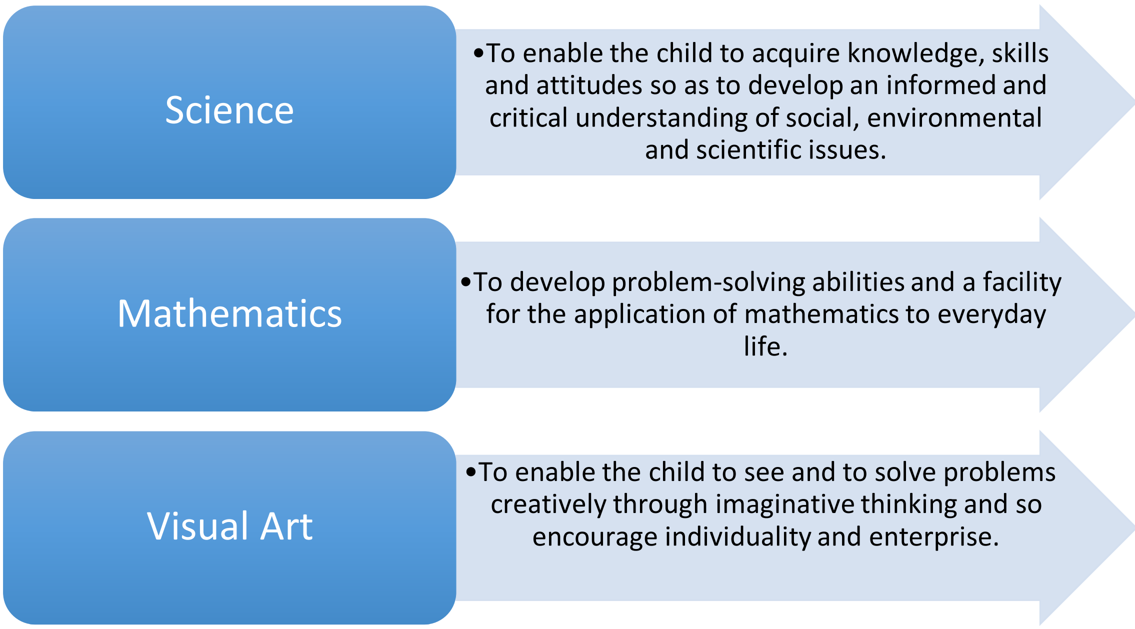
# 3. Continuum of learning

## 3.1. Problem-solving skills in the Early Years and Primary school curriculum

*Aistear, the Early Childhood Curriculum Framework* (National Council for Curriculum and Assessment, 2009a) draws attention to the fact that early learning is not just important in its own right, but that it also lays important foundations for later learning. Aistear contains numerous references to problem solving, a core skill for anyone studying any of the technology subjects and it does not confine problem solving to a discrete area, but rather presents it as being an aspect of learning across a range of areas.

While the Primary School Curriculum does not contain a technology subject as such, several of the subjects lend themselves to the teaching of skills that would be beneficial to students who progress to study any of the technology subjects at second level. A discussion paper produced by the Irish National Teachers' Organisation (INTO) makes reference to the positive values of teaching problem-solving skills in mathematics, 'a child's early mathematical experience and experience of problem solving will underpin future development of learning' (Irish National Teachers' Organisation , 2013, p. 42)

*Figure 3 - Links to Primary School Syllabuses*



## 3.2. Technology subjects at post primary level

**Junior Cycle**

The first stage of post-primary schooling that learners encounter is junior cycle which is:

> *a three-year programme that builds on the young person's educational experience at primary school by offering a broad, balanced and coherent programme of study across a wide range of curriculum areas*

(National Council for Curriculum and Assessment, 2009b, p. 6)

In section 1.2 above, the technology subjects available to students at junior cycle are outlined. The ESRI report, *Pathways through the Junior Cycle: the experiences of second year students* (Smyth, Dunne, McCoy, & Darmody, 2006) found that the learning experience of students was more positive where the learning is organised in an active, project-like way. This related to subjects such as Art, the technology subjects, Home Economics, Physical Education and Music.

The ESRI study *The experiences of students in the third year of junior cycle and in transition to senior cycle: Summary and commentary* (2007, p. 21) found that

> *The level of interest in subjects with a practical orientation is striking. Subjects like materials technology (wood) art, home economics and physical education may be favoured by students for a number of reasons: they are activity-based, involve learning by doing, have more varied learning environments and, in the case of examination subjects, have assessment methods that include a practical dimension.*

The study also commented that

> *The contribution these subjects can make to student motivation and engagement are considerable. That schools should be encouraged and supported to make these subjects accessible to the majority of their students is beyond question*

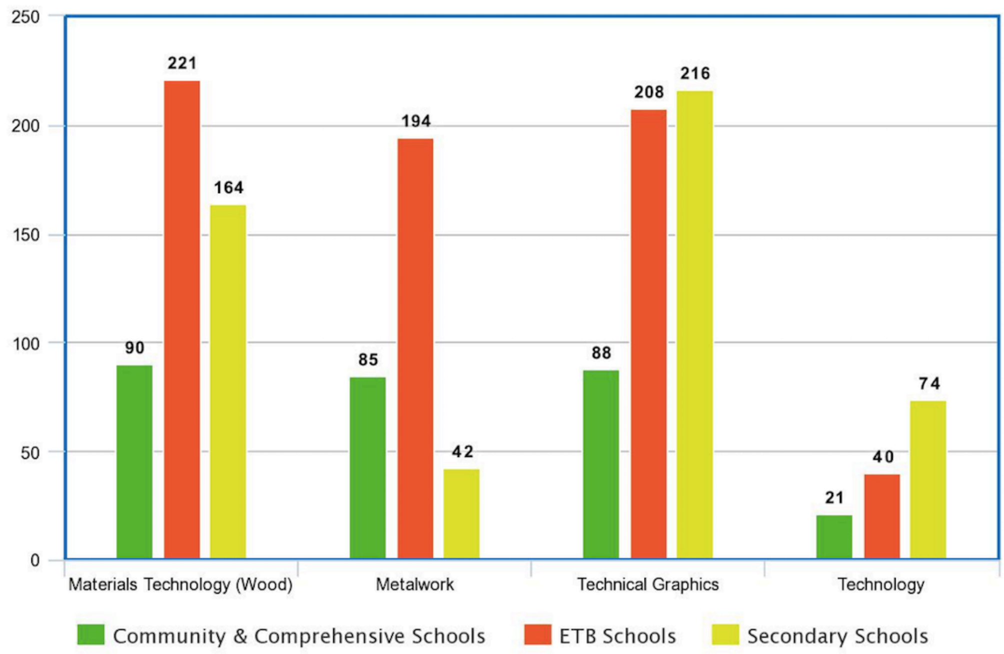
(National Council for Curriculum and Assessment, 2007, p. 21)

These reports not only highlight that students enjoy subjects with a practical application but also that the practical nature or active learning significantly increases students' motivation and engagement with the subject.

It is worth noting that not all schools offer these subjects as part of their curriculum. Appendix 2, illustrates the percentage uptake of each subject and a breakdown of schools that offer these subjects. On further inspection of the Junior Cycle data, it is apparent that:

- Metalwork is still poorly represented in the secondary and community and comprehensive schools. There may be numerous reasons for this but they almost certainly include factors such as lack of resources, shortage of qualified staff, lack of workshop space and the lesser academic value placed on the subject. Materials Technology (Wood) is primarily offered by the Education and Training Board (ETB) schools, but has a greater presence in secondary schools than Metalwork.
- The representation of Materials Technology (Wood) and Technical Graphics in secondary schools could be linked to the traditional options where some secondary schools prior to 1966 offered these two subjects as part of their curriculum.
- Technology as a subject is poorly represented in all school types compared to the other technology subjects.

*Figure 4 - Number of schools offering the technology subjects in 2016*




In the 2017/2018 school year, the number of second level schools registered are:

- Community and Comprehensive = 96 schools
- ETB = 241 schools
- Secondary Schools = 374 schools

### Senior Cycle

*Figure 5 - Senior Cycle technology subject options*

**Leavng Certificate**

- Construction Studies
- Design and Communication Graphics
- Engineering
- Technology

**Leaving Certificate Applied**

- Engineering
- Graphic & Construction Studies
- Technology

Learners at senior cycle can currently opt for a two or three-year senior cycle, leading to the Leaving Certificate qualification. They can take an initial Transition Year programme and/or proceed directly to one of the Leaving Certificate options in Figure 5 and take the final examination after two years. The purpose of senior cycle is to 'develop each student's potential to the full and to equip him or her for further education or training, or for the world of work' (Department of Education and Science, 2004, p. 2)

While the Senior Cycle technology subjects could be seen as a transition from the technology subjects studied at junior cycle, the figures in table 9 seem not to reflect this.

*Table 9 - Percentage of students sitting technology subjects at Senior Cycle in 2016*

| Subject | 2008 | 2012 | 2016 |
|---|---|---|---|
| Construction Studies | 18% | 17% | 15% |
| Design and Communication Graphics* | 11% | 11% | 10% |
| Engineering | 10% | 10% | 10% |
| Technology[1] | - | 2% | 3% |
| | | | |
| Engineering (LCA) | 26% | 23% | 25% |
| Graphic and Construction Studies | 41% | 44% | 47% |
| Technology (LCA) | 8% | 5% | 7% |

* In 2008 Technical Drawing was examined

[1] There are no figures available in 2008 as the subject was only introduced in 2007

The relatively low uptake of the technology subjects at senior cycle may be the result of a low uptake of the subjects at junior cycle and can have a profound influence on the uptake at third level[2].

## 3.3. Section summary

The early years of education do not include the study of technology as a subject, but do teach the foundational skills that lend themselves to the subject area in later years.

At second level, the students are exposed to the technology subjects and research shows that students enjoy the subjects because of their practical nature. The main studies reviewed only focused on the student experience of the subjects in their current form and did not explore attitudes or desired/possible changes to the subjects.

Observations made on the schools offering the technology subjects at junior cycle show similar trends to that of the pre-1966 era and this raises the question of whether, in the intervening period, schools have simply maintained a focus on the subjects they traditionally offered.

The lack of continued uptake in the study of the technology subjects from junior cycle up to further education and beyond, is a concern in an increasingly technological society.

[2] In 2016, only 11% of new entrants in third level took up places in the field of engineering, manufacturing and construction (Higher Education Authority, 2017)

# 4. International trends in technology education

Ireland is almost unique in presenting its technology education as four, stand-alone subjects. Internationally it is more common for schools to offer one subject, encompassing a range of technology learning, with a title like ‘Design and Technology’ or ‘Technological Education’. The following summarises the provision of technology education at lower secondary in a number of jurisdictions and highlights the similarities and differences between them.

## 4.1. Scotland

*Table 10 - Summary of Design and Technology in Scotland*

| | |
|---|---|
| Subject Name: | Design and Technology |
| Qualification: | National Certificate |
| Age when studied: | 14 – 15 |
| Learning Outcomes: | The aims of the Course are to enable learners to:<br>▪ develop skills in producing and interpreting sketches, drawings and diagrams<br>▪ develop skills in practical model making and construction<br>▪ develop skills in testing and simple evaluation of models<br>▪ apply safe working practices in a workshop or similar environment<br>▪ develop knowledge of basic engineering ideas<br>▪ The course introduces learners to ideas and skills which they may then choose to take forward through further study in the technologies curriculum area. |
| Key Principles: | The course is divided into three mandatory units:<br>▪ Graphics for Design<br>▪ Designing and Modelling<br>▪ Constructing and Testing |
| Assessment: | Scottish Qualification Authority does not specify the methods of assessment to be used; teachers should determine the most appropriate method for their learners and develop an assessment that covers all learning outcomes on each unit |

| | |
|---|---|
| Progression: | Following on from studying Design and Technology, the subject divides into three areas and the student can opt for the following fields of study:<br>Graphic Communication<br>Engineering Science<br>Design and Manufacture |

## 4.2. Ontario, Canada

*Table 11 - Summary of Technological Education in Ontario, Canada*

| | |
|---|---|
| Subject Name: | Technological Education |
| Qualification: | Ontario Secondary School Diploma |
| Age when studied: | 14 – 16 |
| Learning Outcomes: | The goals of the technological education curriculum are to enable students to:<br>▪ gain an understanding of the fundamental concepts underlying technological education<br>▪ achieve the level of technological competence they will need in order to succeed in their postsecondary education or training programmes or in the workplace<br>▪ develop a creative and flexible approach to problem solving that will help them address challenges in various areas throughout their lives<br>▪ develop the skills, including critical thinking skills, and the knowledge of strategies required to do research, conduct inquiries, and communicate findings accurately, ethically, and effectively<br>▪ develop lifelong learning habits that will help them adapt to technological advances in the changing workplace and world<br>▪ make connections that will help them take advantage of potential post-secondary educational and work opportunities. |
| Key Principles: | ▪ Exploring Technologies*<br>▪ Communications Technology<br>▪ Computer Technology<br>▪ Construction Technology<br>▪ Green Industries<br>▪ Hairstyling and Aesthetics |

| | |
|---|---|
| | ▪ Health Care<br>▪ Hospitality and Tourism<br>▪ Manufacturing Technology<br>▪ Technological Design<br>▪ Transportation Technology<br><br>* Students must study the Exploring Technologies module in grade 9 and chose one of the remaining ten to study in grade 10 |
| Assessment: | Students are continuously assessed under the following headings:<br>▪ Knowledge and Understanding<br>▪ Thinking<br>▪ Communication<br>▪ Application<br>Teachers have access to an achievement chart (see Appendix 3) that guides them towards fair assessment of student learning. |
| Progression: | Students continue education up to grade 12 and can continue to study the module chosen at year 10 with a deeper focus relating to college/university and the workforce. |

## 4.3. England, Wales and Northern Ireland

*Table 12 - Summary of Design and Technology in England, Wales and Northern Ireland*

| | |
|---|---|
| Subject Name: | Design and Technology |
| Qualification: | GCSE |
| Age when studied: | 14 – 16 |
| Learning Outcomes: | Courses based on this specification must encourage students to:<br>▪ demonstrate their understanding that all design and technological activity takes place within contexts that influence the outcomes of design practice<br>▪ develop realistic design proposals as a result of the exploration of design opportunities and users' needs, wants and values<br>▪ use imagination, experimentation and combine ideas when designing<br>▪ develop the skills to critique and refine their own ideas whilst designing and making |

| | |
|---|---|
| | ▪ communicate their design ideas and decisions using different media and techniques, as appropriate for different audiences at key points in their designing<br>▪ develop decision making skills, including the planning and organisation of time and resources when managing their own project work<br>▪ develop a broad knowledge of materials, components and technologies and practical skills to develop high quality, imaginative and functional prototypes<br>▪ be ambitious and open to explore and take design risks in order to stretch the development of design proposals, avoiding clichéd or stereotypical responses<br>▪ consider the costs, commercial viability and marketing of products<br>▪ demonstrate safe working practices in design and technology<br>▪ use key design and technology terminology including those related to: designing, innovation and communication; materials and technologies; making, manufacture and production; critiquing, values and ethics. |
| Key Principles: | The course is divided into three core areas:<br>▪ Core technical principles<br>▪ Specialist technical principles<br>▪ Designing and making principles<br>The specialist technical principles can be taught through one or more of the follow fields: papers and boards, timber based materials, metal based materials, polymers, textile based materials, electronic and mechanical systems. |
| Assessment: | 2 hour written exam – 50%<br>Task – 50% (this is marked by the teacher and externally moderated) |
| Progression: | Following on from studying Design and Technology, students can opt to study Design and Technology: Product Design at A Levels |

## 4.4. New South Wales, Australia

*Table 13 - Summary of Design and Technology in New South Wales, Australia*

| | |
|---|---|
| Subject Name: | Design and Technology |
| Qualification: | School Certificate Record of Achievement |
| Age when studied: | 12 – 16 |
| Learning Outcomes: | Students will develop:<br>▪ knowledge and understanding of design concepts and processes<br>▪ understanding and appreciation of the impact of past, current and emerging technologies on the individual, society and environments<br>▪ knowledge and understanding of the work of designers and the issues and trends that influence their work<br>▪ knowledge and understanding of and skills in innovation, creativity and enterprise<br>▪ skills in communicating design ideas and solutions<br>▪ knowledge and understanding of and skills in managing resources and producing quality design solutions. |
| Key Principles: | Core content is divided into areas that must be integrated when developing units of work. The areas are:<br>▪ a holistic approach<br>▪ design processes<br>▪ activity of designers. |
| Assessment: | Students are continuously assessed with particular focus on a design project that involves the design, production, documentation and evaluation of solutions. |
| Progression: | Students have the option to continue education on completion of the School Certificate Records of Achievement. Design and Technology is a subject option, but other options such as Engineering Studies, Metal and Engineering, and Construction now become available to students. |

## 4.5. Section summary

The practice of other jurisdictions is to approach technology education as one subject/programme. The England, Wales, Northern Ireland and the New South Wales models have undergone the most recent reforms of the jurisdictions studied.

In each jurisdiction design, creativity, and critical thinking are at the core of learning alongside the skill/craft element. The students are encouraged to develop holistic skills that will take them beyond a terminal assessment/project.

In general, there is less focus on the terminal examination than in Ireland (aside from the England, Wales, Northern Ireland model) and the continuous assessment model is adopted by the majority of jurisdictions.

Each jurisdiction’s curriculum sets out a clear path that takes students through a learning process that seeks a balance of soft skills and the craft skills such as drawing, hand skills and tool skills

# 5. Education for the 21st century

> *For generations, Vocational Education Committee (VEC) schools provided those who eventually became tradespersons with their basic education through the Group Certificate and, later on, the Intermediate/Junior Certificate. Critically, also, the VEC schools provided many who would take up apprenticeships and similar types of employment with their core vocational skills – woodwork, metalwork, mechanical drawing, home economics, typing and book-keeping.*

(Education and Training Boards Ireland, 2013, p. 2)

As outlined in the previous section, the technology subjects evolved from a strongly vocational, practical base. Looking forward, any development in education for the twenty-first century needs to be cognisant of a broader set of skills required by students. In January 2016, research by the World Economic Forum estimated that '65% of children entering primary school today will ultimately end up working in completely new job types that don't yet exist.' (World Economic Forum, 2016, p. 1). The technology classroom can no longer be an environment for the teaching of the skills particularly associated with trades or similar types of employment. The technology subjects should of course encourage processing skills but also develop key skills such as problem solving and critical thinking that can contribute significantly toward the learning in other technology subjects and the wider learning of the student.

Many institutions and organisations have endeavoured to compile a comprehensive list of the skills and competences needed by 21st century learners. In 2006, the European Union published a reference framework for key competences for lifelong learning. Among those skills listed are 'technological competence' and 'learning to learn'. These competences refer to the necessity of developing a problem-solving attitude, the ability to reflect critically and work collaboratively (EU, 2006). The Global Digital Citizen Foundation has delivered presentations to educators and administrators in several countries over many years. It has surveyed education practitioners on the most important 21st century skills needed by students. The common responses compiled include:

- Problem-solving
- Creativity
- Analytic thinking
- Collaboration
- Communication
- Ethics, action, and accountability

(Crockett, Jukes, & Churches, 2011)

While the Assessment and Teaching of 21st Century Skills project promoted by Intel, Cisco and Microsoft, identified ten key skills divided into four broad categories, a similar spectrum of competences is evident.

*Figure 6 - Spectrum of competences*

| | |
|---|---|
| **Ways of Thinking**<br>Creativity and innovation<br>Critical thinking, problem solving, decision-making<br>Learning to learn/metacognition (knowledge about cognitive processes) | **Tools for Working**<br>Information literacy<br>Information and communication technology (ICT) literacy |
| **Ways of Working**<br>Communication<br>Collaboration (teamwork) | **Ways of Living in the World**<br>Citizenship – local and global<br>Life and Career<br>Personal and social responsibility – including cultural awareness and competence |

(Griffin, Care, & McGaw, 2012)

The inclusion of competences such as personal and social responsibility, global citizenship, ethics and accountability raise questions regarding sustainability and ethics that will have implications for courses that produce artefacts. The sustainability, or desirability, of maintaining a major focus on artefact production has been questioned in research (McGarr, 2010). The national strategy on Education for Sustainable Development (Department of Education and Skills, 2014) requires the integration of ESD principles across curriculum areas as they are reviewed. This has implications for the development of the specifications for the technology subjects.

A recent study, *The Role of Engineering Design in Technological and 21st Century Competencies Capacity Building: Comparative Case Study in the Middle East, Asia, and Europe* (Abdulwahed & Hasna, 2017, p. 2) found that

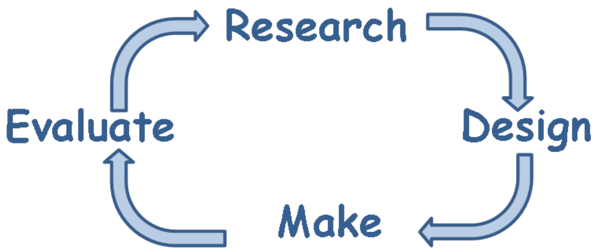
> *One of the best approaches of developing an all-rounded 21st century engineering talent is to embed existing engineering curriculum and co-curriculum with technical approaches that lead to a wide set of competencies development; design courses, projects, and co-curriculum activities can be a well-suited platform for this embedded approach.*

In designing a specification for the technology subjects to suit the needs and requirements of students in the 21st century, the inclusion of these skills and competences would seem to be an essential first step.

## 5.1. Design as a problem-solving tool

Many of the competencies identified above such as problem-solving, creativity, innovation, analytical or critical thinking, collaboration and social responsibility can be encompassed within the design process. The design process is often interpreted as a simple process such as:

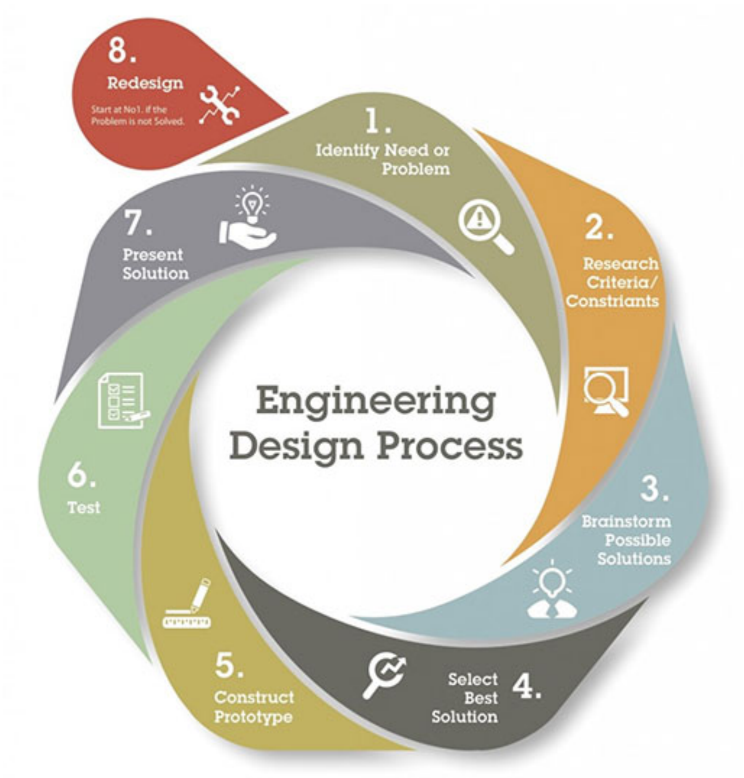
*Figure 7 - Basic design process*




To examine the design process in greater detail, one would need to explore the design process as a problem-solving exercise, since it presents itself as a much more complex process that can be used to solve problems not only within the technology subjects, but across a range of subjects and tasks.

In the diagram below for example, the engineering design process has eight iterative stages which can be used to solve a problem/task.

*Figure 8 – Example of engineering design process*




(Jenkins, 2015)

Developing design skills does more than just enable one to physically create an artefact. The skills involved can be used as part of an effective approach to problem solving. 'At the heart of design thinking is an approach to problem-solving that is built around inquiry, reflection, and modification' (Sterman, 2015, p. 3)

The teaching and practice of design skills can equip learners with skills that can be utilised beyond the classroom.

> *Design Thinking is an approach to learning that focuses on developing children's creative confidence through hands-on projects that focus on empathy, promoting a bias toward action, encouraging ideation and fostering active problem-solving – skills and competencies*

(Kwek, 2011, p. 4)

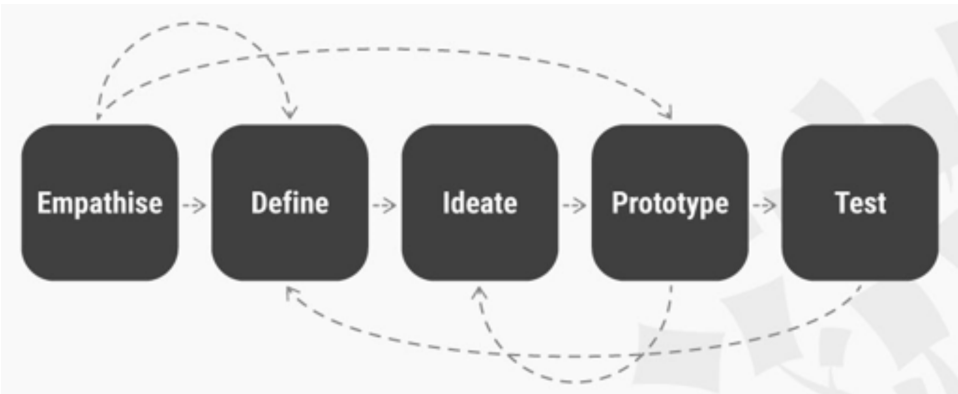
In a review of *Technology Education in Ireland; a changing technological environment promoting design activity* (2014), Leahy and Phelan found that 'Irish policy makers were striving to prosper beyond vocational education towards a holistic design-based education' since the 2006 reform in the technology subjects at senior cycle. This has not been reflected so far in the current Junior Cycle subjects. Design is practiced in response to assessment requirements rather than as an approach to problem-solving. This is due to many factors, such as a traditional vocational emphasis, the lack of a design pedagogy for education, and an assessment-driven culture. As a consequence, the approaches toward design result in a dominant focus on the artefact rather than the problem/process.

The design process when used as a generic tool to solve problems, rather than the specific engineering example, can be represented in five stages:

1. Empathise – to gain an empathic understanding of the problem you are trying to solve
2. Define – putting together the information you have created and gathered during the Empathise stage. You will analyse your observations and synthesise them in order to define the core problems
3. Ideate - identify new solutions to the problem statement you've created and you can start to look for alternative ways of solving the problem.
4. Prototype – production of several inexpensive, scaled down versions of the solution or specific features found within the solution
5. Test - test the complete solution using the best solutions identified during the prototyping phase.

Even though the process is presented in a linear, step by step manner, it is intended that the process is carried out in a more flexible and non-linear fashion such as the version illustrated by the Interaction Design Foundation in figure 9.

*Figure 9 - Interaction Design Foundation design process*




(Dam & Siang, 2017)

As part of this process, it is important not to confuse design based learning with project based learning. Combined, they can be used to solve problems and create solutions, but require the learners to have a different approach.

> *Design thinking is different from project-based learning because the problem is not initially identified for the students. Design thinking requires that students identify the problem for themselves. Figuring out which questions to ask and what problems are worth solving*

(Kolk, 2012)

As highlighted in section 4, the international provision of the subject area consistently focuses on the centrality of the design process. In the existing Junior Certificate technology syllabuses, while design is mentioned, it appears not to be central to the experience of the learner.

## 5.2. STEM – Science Technology Engineering Mathematics

> *It is critical that attention is focused on STEM education at second level to ensure that students are equipped to take up opportunities to continue study in STEM areas. without a firm foundation in their STEM education at both primary and post primary there will not be third or further education students interested in seeking to continue their STEM studies*

(Department of Jobs, Enterprise and Innovation, p. 1)

Morrison (2006) suggests that a student with a well-developed STEM education is a problem-solver, innovative, an inventor, self-reliant, a logical thinker, technologically literate, and able to relate his or her own culture to the learning – all characteristics needed for the 21st century learner.

STEM is an idea based on educating students in the four disciplines (science, technology, engineering and mathematics) as a holistic approach rather than four discrete areas. 'Innovation 2020', Ireland's strategy for Research and Development, Science and Technology, highlights the critical importance of excellence in STEM Education to ensure a continuous pipeline of talent to meet future development.

I WISH, an initiative to inspire, encourage and motivate young female students to pursue careers in STEM recently carried out one of the largest surveys ever of 2397 Irish secondary school girls aged 14–17 years of age on their attitudes to STEM; what influences them and what is important to them as they consider their Leaving Certificate subject choices and future career paths. The *Female students' attitudes to stem (2017)* survey presented some interesting, yet concerning statistics around the female student perspective on STEM. The potential for 'real world' application was highlighted as an important factor for students; a need to 'Integrate into the syllabus a clear link between subjects and actual ‘real world’ application. This year many teachers also expressed the value of this connection for them and their students (I Wish, 2017, p. 26). Again, within the survey, it showed that study of STEM is still a continuing issue in respect to gender

> *The uptake level is still disappointing with 49% not taking any STEM subject to Leaving Certificate level. 82% of students report that they want a career where they can help other people, 94% a career that is interesting and 89% a career that they will be good at. We know STEM careers can deliver all of these but young girls don’t.*
>
> (I Wish, 2017, P. 19)

In November 2016, the STEM Education Review Group, set up to review STEM education in Irish schools, published its report. It highlighted the benefits of inquiry-based learning and problem-based learning and links this style of learning to real life application.

> *Inquiry-Based Learning (IBL) and Problem-Based Learning (PBL) approaches encourage students to engage with and understand scientific and mathematical concepts in the context of real applications. It is common to all STEM subjects, although there are specific differences for particular subjects.*
>
> (The STEM Education Review Group, 2016, p. 35)

Even though the report specifically references scientific and mathematical concepts, studies have shown inquiry-based learning and problem-based learning is not just restricted to these areas, but is applicable across all the STEM subjects, including the technology based subjects. The majority of research around STEM focuses primarily on the sciences and mathematics, while even though they are considered equally important, technology and engineering studies are less referenced within the Irish second level education context.

> *While concerns in relation to science and mathematics are clearly evident in current literature, there does not appear to be a comparable level of interest in the technology- related subjects at second-level.*
>
> (McGarr & Lynch, 2015, p. 55)

The Review Group report later refers to assessment and asserts that ‘Assessment strongly influences the learning process and the way students think about themselves’ (The STEM Education Review Group, 2016, p. 36). Currently, students who study the technology subjects with a project element often regard the final artefact in third year as a measure of their learning and the learning process needed to produce this output is not valued. The report recommended that STEM subjects should have assessments that are *designed to measure students' ability to collaborate, diagnose problems, critique experiments, plan investigations, research information, construct models, debate with peers, form coherent arguments and create and co-create new content.*

The technology subjects lend themselves naturally to these elements of assessment and align themselves with the eight key skills of the *Framework for Junior Cycle* (see appendix 4). The Framework intends that students will acquire and enhance their proficiency in the eight key skills and that 'they will be brought to life through the learning experiences encountered by students' (Department of Education and Skills, 2015, p. 13) and that this should be evident in the assessment approaches used in the classroom and in examinations. Any future development of the subject area should be cognisant of this range of skills needed by students.

## 5.3. Changes to the apprenticeship model

Through the National Skills Strategy 2025, the Action Plan for Education 2017 and as part of the current programme for government, Ireland aims to significantly grow work-based learning over the coming years using the apprenticeship and traineeship model of learning and skills development.

The apprenticeship model was primarily focused on craft and vocational schools were considered a 'pre-training' stage to this.

*The original purpose of the VECs was to administer continuation and technical education for 14- to 16-year-olds, where continuation education was defined as 'general and practical training in preparation for employment in trades', while technical education was described as 'pertaining to trades, manufacturers, commerce and other industrial pursuits*

(Education and Training Boards Ireland, 2013, p. 2)

Even though the minimum educational requirements for a person to be eligible still requires that the student be at least 16 years of age and have a minimum of grade D in five subjects in the Junior Certificate or equivalent exam[3], companies are now self-regulating their criteria for selection of apprentices and are looking for a minimum of a Leaving Certificate or equivalent qualification. Companies that offer specific trades such as electricians, are now going a step further and are setting specific subject requirements. 'Employers typically seek applicants who have completed Leaving Cert

[3] There are alternative options to those who do not have a junior certificate qualification such as pre-apprenticeship courses. Those over 18 years of age with three years' experience qualify but may be asked to sit an assessment interview

including Maths (with at least a grade C3 in Ordinary Level Maths) and preferably Physics' (Construction Industry Federation, 2017).

While they were once subjects developed to aid a learner in developing skills relevant to apprenticeships and/or the working world, the technology subjects are no longer serving that purpose. The new junior cycle technology subjects will need to reflect the needs of the changing times and diverge from the idea that the technology subjects are singularly a pathway to apprenticeships.

In the *Education and Training Boards Ireland (ETBI) Submission to Department of Education and Skills on The Future of Apprenticeship in Ireland (2016, p. 2),* the notion of moving away from the 'classical' apprenticeship model was raised.

> *In a world where change is the only constant, it will not be sufficient to provide apprentices with the skill set to go on doing the same things in the same way; we will need to provide them with the knowledge, skills, competences and dispositions to solve new problems, as they emerge, in new ways.*

It is only in more recent months, that five of the apprenticeships[4] have undergone changes that move the model away from a predominantly craft focus and realigns training with the flexible and changing skills and competences needed in a modern work force. These changes include moving to portfolio assessment and inclusion of soft skills modules on team leadership and communications at each of the job phases.

## 5.4. Section summary

The skills closely associated with the content of the current technology subjects need to be reviewed considering the identified needs of a 21st century learner.

There is a growing emphasis on the importance of STEM subjects but while there is significant and ongoing emphasis on Science and Mathematics, the Technology and Engineering elements tend to receive less attention in this context. The junior cycle reform presents a timely opportunity to emphasis the role of Technology and Engineering in second level education.

[4] Carpentry and joining, plumbing, electrician, metal fabrication and heavy goods vehicle mechanics

It can no longer be assumed that a junior cycle qualification will guarantee a learner a position on an apprenticeship programme, a traditional route taken by many students of the technology subjects. The role of the technology subjects therefore can no longer be seen, singularly, as the pathway to an apprenticeship and there is a need to change the focus to a more balanced curriculum.

The teaching of design skills and enabling students to engage in a holistic design process is a significant aspect of a learner's experience whether they are producing artefacts or working towards a solution of a problem/task.

# 6. Emerging themes

This section of the background paper looks at the emerging themes from the preceding sections that the development groups for the junior cycle technology subjects will need to take into account in their deliberations.

## 6.1. The balance of the subject craft and design

The craft of the technology subjects, be they the bench skills in a practical room or the drawing skills in Technical Graphics, appear to be the main focus of learning across all the subjects. International practices show that there is a need to balance the craft of a subject with skills such as designing and problem solving to give learners a holistic learning experience. This is reflected in the approach that Seirbhísí Oideachais Leanunaigh Agus Scileanna (SOLAS), formerly FÁS have taken to reform the Irish apprenticeship structures to improve the learning experience of its participants and develop the necessary skills. The apprenticeship approach, which was once a dominant craft-orientated model, has now started the process of reviewing their programmes to include soft skills to ensure that learners can compete and survive in the continuously changing world.

The teaching of design as a process equips the learner with skills that are adaptable across the spectrum of education and the world of work.

## 6.2. The gender divide

It is evident from the analysis of data that the subjects are predominantly taken by boys. This raises a number of questions.

A study by the Economic and Social Research Institute on *Gender and Subject Choice* found that strong gender stereotyping was evident in student attitudes to the technological subjects (Darmody & Smyth, 2005). In their current form, the subjects typically depict a male-orientated environment focused on craft and production, which could lead to stereotyping of the subjects. If the technology subjects exhibited a more holistic approach to learning, they might create a different impression of the subjects and alter their current depiction as male orientated. It may also encourage single sex schools to include the technology subjects as a curricular option. Access to resources associated with the teaching of technology subjects also has a role in limiting the number of schools choosing to offer the subjects for the first time.

The traditional timetabling where schools opt to pair the technology subjects opposite subjects perceived to be traditionally more associated with female participation restricts the growth of female uptake in the schools. Traditional timetabling arrangements also reinforce the previously mentioned stereotyping of the subjects as a male-orientated subjects.

## 6.3. The student voice

In preparing this paper a small number of students of the subjects were interviewed on their views of the subjects in their current and possible future form. Two schools were available to participate; both were mixed schools under the auspices of an Educational and Training Board. Where one school catered mainly for urban students, the other catered for both urban and rural students. All participants studied a minimum of one of the technology subjects with some studying up to three of the technology subjects.

A number of the students highlighted similar areas that they enjoyed across all four of the technology subjects, areas such as: the practical nature of the subjects, getting to work outside the 'normal classroom' and getting to engage in the making of projects. When asked what they would see as beneficial changes to any of the subjects, the students offered a number of their own ideas, some of which were similar across a number of students. They questioned the place of the theory aspect of the subjects. While they did not express an interest in removing it in its entirety, they suggested making it more relevant to everyday life and current to the times.

A specific idea relating to technical graphics was suggested – increased use of ICT in the subject. The student had completed his Junior Certificate and felt that it would have been beneficial if he had studied some form of SolidWorks as part of his Junior Certificate. This was not only from the point of view of the experience of studying Technical Graphics, but it could have been used in a cross-curricular approach, by incorporating computer drawings into his portfolio work as part of his Materials Technology (Wood) project. Another student also suggested that to take some of the pressure from the final Technical Graphics exam, they should be given the opportunity to engage in some form of project work to improve the experience of the subject and 'make it more of a practical subject'.

One female student felt that the subject names, in particular, Metalwork, put her off studying the subject and she would have been more open to the subject if the name reflected all that the subject involved. A recommendation from one group of students suggested moving away from just focusing on 'metal' and 'wood' in the name of the subject and moving to something more rounded such as 'design and general engineering' or 'wood and design'. This idea also arose in 2004 when the technology subjects were reviewed (NCCA, 2004, p. 16), where the study found that 'a number of new proposals emerged for naming the new syllabuses/subjects'.

Arising from the talk of design, a discussion took place in relation to the design element of the subjects. Students of Metalwork felt that there was limited opportunity to design their own final project and that the subject could give the students more scope to design parts of their own project.

An interesting link was made between one student's response to the question on 'what skills they should have developed on completion of the Junior Certificate' and the skills desired of a 21st Century learner. It was his opinion that students completing the Junior Certificate should have developed a number of skills focused around communications, team working, time management and being able to adapt to any situation within the classroom.

## 6.4. Continuity across the subjects

As mentioned, Ireland is unique as it offers the technology subjects as four separate subjects. The process of developing new junior cycle specifications presents the opportunity to align the subjects more and create a common structure around which the individual subjects can be developed. Students should be engaging in life skills such as problem solving, inquiry based learning and reflection across all the technology subjects in a related approach. Students should be encouraged to explore the subjects through experimentation, and encouraged to adapt the skills and learning of any of the technology subjects in a cross curricular approach.

# 7. Subject specifications in the new junior cycle

While some may have distinct characteristics, arising from the area of learning involved, all junior cycle specifications, for subjects and short courses, will have several features in common. They will:

- Be outcomes based
- Reflect a continuum of learning with a focus on learner progression
- Set out clear expectations for learning
- Provide examples of those expectations
- Include a focus on all eight key skills
- Strive for clarity in language and for consistency in terminology.

To improve the connection with learning and teaching in primary school, these features are shared with the Primary Curriculum. The specification for each junior cycle subject and short course will include:

| | | |
|---|---|---|
| 1 | Introduction to junior cycle | This will be common to all specifications and will summarise the main features of the *Framework for Junior Cycle* |
| 2 | Rationale | This will describe the nature and purpose of the subject as well as the general demands and capacities that it will place on, and require of, students.<br><br>The text will, as appropriate, aim to draw attention to challenges and any access issues associated with study of the subject for students with specific needs or disabilities. |
| 3 | Aims | A concise aim for the subject will be presented |
| 4 | Links with<br>Statements of learning | How the subject is linked to central features of learning and teaching at junior cycle will be highlighted and explained. |

| | | |
|---|---|---|
| 5 | Overview<br>Strands<br>Learning outcomes | An overview of the subject will illustrate how it is organised and will set out the learning involved in strands and learning outcomes. |
| 6 | Expectations for students | These will be linked with groups of learning outcomes and will relate to examples of student work. The examples will be annotated, explaining whether the work is in line with, ahead of, or behind expectations for students. |
| 7 | Assessment and reporting | This section refers to both formative and summative assessment. It outlines the assessment component/s through which students will present evidence of learning on an ongoing basis, and for the purposes of recording achievement for the Junior Cycle Profile of Achievement (JCPA) [5]<br>This description of assessment is supplemented by separate assessment guidelines for use in second and third years. |

[5] The JCPA is the new award for all junior cycle students. It will replace the current award, the Junior Certificate.

# 8. Brief for the review of the junior cycle technology subjects

The review of the junior cycle technology subjects

- Materials Technology (Wood)
- Metalwork
- Technical Graphics
- Technology

will lead to new specifications presented in line with the template described above.

The specifications will be at a common level and will be designed to be taught and assessed in a minimum of 200 hours and structured or organised around strands and learning outcomes.

The specifications will be developed in alignment with the statements of learning, including that the student:

- Creates, appreciates and critically interprets a wide range of texts (statement of learning 3)
- Creates and presents artistic works and appreciates the process and skills involved (statement of learning 4)
- Recognises the potential uses of mathematical knowledge, skills and understanding in all areas of learning (statement of learning 15)
- Devises and evaluates strategies for investigating and solving problems using mathematical knowledge, reasoning and skills (statement of learning 17)
- Observes and evaluates empirical events and processes and draws valid deductions and conclusions (statement of learning 18)
- Values the role and contribution of science and technology to society, and their personal, social and global importance (statement of learning 19)
- Uses appropriate technologies in meeting a design challenge (statement of learning 20)

- Applies practical skills as she/he develops models and products using a variety of materials and technologies (statement of learning 21, all technology subjects)
- Takes initiative, is innovative and develops entrepreneurial skills (statement of learning 22)
- Brings an idea from conception to realisation (statement of learning 23)
- Uses technology and digital media tools to learn, work and think collaboratively and creatively in a responsible and ethical manner (statement of learning 24)

It will be completed for autumn 2018.

The development of the specifications will:

- take account of current research and developments in the field of technology education, emerging understandings of the content and nature of technology in the context of students' stages of development, and the need for alignment with the ongoing development of the literacy and numeracy strategy.
- address continuity and progression. It will consider whether the technology subjects should be taught from a broader, general base in first year with a particular focus on consolidation of learning from primary school and on the development of students' understanding of cross-curricular links, skills and attitudes that the technology subjects can form when combined with other subjects. For example, the use of problem based and inquiry based learning to solve problems, apply research skills to project work with the inclusion of reflective practice and the application of technology in our everyday lives.
- consider the appropriate balance between relevant craft and process skills, design skills, and problem-solving skills., to help the students become more innovative and independent learners, which is required by the evolving nature of the subjects. The relevance and scope of theory to be included in the specifications should also be reflected in this evolution.

More specifically, the development of the new specifications will consider:

- how to encourage student engagement, inclusion and motivation within the subjects
- how practical, inquiry-based teaching and learning will be promoted within the subjects
- how the subjects will assist in the development of student self-directed learning

- how to assist in the development of the concept of lifelong learning within the technology subjects
- assessment approaches that align appropriately with the learning outcomes of the specification
- how to develop students' conceptual, collaborative and communication skills
- how to reduce the gender imbalance in the uptake of the subjects, the alignment between the learning within the subjects and the rapidly evolving technology environment
- how design as a skill might be best embedded in each specification
- the role of ICT in the learning and teaching of the subjects
- which craft skills should be learned and how they can best be represented in the specification
- how to create a cohesive learning experience of the technology subjects

The work of the technology subject development groups will be based, in the first instance, on this brief. In the course of its work and discussions, elaborations of some of these points and additional points may be added to the brief.

# Appendices

## Appendix 1: Aims of the Junior Certificate Technology Subjects

| **The Materials Technology (Wood) syllabus aims** |
|---|
| To develop a creative approach to problem solving in the design process through designing, making and evaluating, and to promote initiative, enquiry and discrimination<br><br>To stimulate the development of a range of manipulative skills through processing wood and other materials<br><br>To contribute to the development of graphic and other appropriate communication skills<br><br>To promote technological awareness and the exercise of value judgements of an aesthetic, technological and economic nature<br><br>To encourage self-confidence, enthusiasm and a sense of achievement, through the design and execution involved in practical project work<br><br>To encourage the acquisition of a body of knowledge appropriate to wood craft and technology through analysis, synthesis and realisation<br><br>To contribute to the pupil's appreciation of ecological and environmental factors and use of natural resources. |
| **The Metalwork syllabus aims** |
| To make an essential contribution to general educational development<br><br>To link observation and action with ingenuity and creativity and with problem-solving and higher level responses<br><br>To develop work-related disciplines<br><br>To provide insights into engineering technology at a variety of levels<br><br>To provide a basis for career decision-making and further studies. |
| **The Technical Graphics syllabus aims** |
| To stimulate the pupil's creative imagination through developing their visuo-spatial abilities<br><br>To encourage the development of the cognitive and practical manipulative skills associated with graphicacy<br><br>To provide pupils with a body of knowledge appropriate to interpreting and communicating spatial information and ideas |

| |
|---|
| To sharpen the pupil's visual perception of their environment and its elements and encourage the exercising of aesthetic value judgments<br><br>To develop basic competency in computer graphics in the context of graphical problem-solving and computer aided design<br><br>To encourage the development of logical and progressive reasoning and enquiry/investigative skills, and the ability to spatialise and visualise two and three dimensional configurations and their elements in the solution of graphical problems<br><br>To help pupils understand the importance of communicating information graphically. |
| **The Technology syllabus aims** |
| To contribute to the student's preparation for life through encouraging the constructive and creative use of such knowledge and transferable skills as might be applicable to solving practical problems<br><br>To contribute to the student's development of qualities of self-reliance, self- confidence, resourcefulness and initiative<br><br>To contribute to the student's preparation for life by stimulating the student's interest and confidence in working safely with equipment and materials<br><br>To develop in the student such skills of visualisation and of manipulation as are involved in designing and making artefacts<br><br>To develop in the student the abilities to make a critical evaluation of a piece of work and to take appropriate action<br><br>To develop the student's knowledge and understanding of communications conventions and of scientific and technological phenomena and terminology<br><br>To develop in the student an appreciation of how technology impacts on society and an understanding of how it might be used to the benefit or detriment of the social and physical environment<br><br>To develop in the student an appreciation that established technological solutions reflect the accumulation of the experience and wisdom of the ages. |

# Appendix 2: Schools offering technology subjects in 2016

| | Single Sex Schools | | Mixed Schools | Total | % of schools offering the subject |
|---|---|---|---|---|---|
| | **Male** | **Female** | | | |
| **Junior Certificate** | | | | | |
| Materials Technology (Wood) | 75 | 1 | 399 | 475 | 67.3% |
| Metalwork | 19 | 0 | 302 | 321 | 45.5% |
| Technical Graphics | 87 | 17 | 408 | 512 | 75.2% |
| Technology | 19 | 0 | 302 | 321 | 45.5% |
| | | | | | |
| **Leaving Certificate** | | | | | |
| Construction Studies | 70 | 3 | 391 | 464 | 67.7% |
| DCG | 85 | 18 | 368 | 471 | 68.8% |
| Engineering | 23 | 1 | 301 | 325 | 47.4% |
| Technology | 19 | 12 | 61 | 92 | 13.4% |
| | | | | | |
| **Leaving Certificate Applied** | | | | | |
| Engineering | 9 | 0 | 85 | 95 | 33.1% |
| Graphic & Construction Studies | 27 | 1 | 128 | 156 | 54.4% |
| Technology | 4 | 2 | 19 | 25 | 8.7% |

## Appendix 3: Example of achievement chart

| Categories | 50–59% (Level 1) | 60–69% (Level 2) | 70–79% (Level 3) | 80–100% (Level 4) |
|---|---|---|---|---|
| **Knowledge and Understanding** – Subject-specific content acquired in each course (knowledge), and the comprehension of its meaning and significance (understanding) | | | | |
| | The student: | | | |
| **Knowledge of content** (e.g., facts, equipment, terminology, materials) | demonstrates limited knowledge of content | demonstrates some knowledge of content | demonstrates considerable knowledge of content | demonstrates thorough knowledge of content |
| **Understanding of content** (e.g. Procedures, technological concepts, processes, industry standards) | demonstrates limited understanding of content | demonstrates some understanding of content | demonstrates considerable understanding of content | demonstrates thorough understanding of content |
| **Thinking** – The use of critical and creative thinking skills and/or processes | | | | |
| | | The student: | | |
| **Use of planning skills** (e.g., identifying the problem, selecting strategies and resources, scheduling) | uses planning skills with limited effectiveness | uses planning skills with some effectiveness | uses planning skills with considerable effectiveness | uses planning skills with a high degree of effectiveness |
| **Use of processing skills** (e.g., analysing and interpreting information, reasoning, generating and evaluating solutions, forming conclusions) | uses processing skills with limited effectiveness | uses processing skills with some effectiveness | uses processing skills with considerable effectiveness | uses processing skills with a high degree of effectiveness |
| **Use of critical/creative thinking processes** (e.g., problem-solving, design, | uses critical/ creative thinking processes with limited effectiveness | uses critical/ creative thinking processes with some effectiveness | uses critical/ creative thinking processes with considerable effectiveness | uses critical/ creative thinking processes with a high degree of effectiveness |

| | | | | |
|---|---|---|---|---|
| and decision-making processes) | | | | |

Appendix 4: Junior Cycle key skills

# 9. Bibliography


Abdulwahed, M., & Hasna, M. O. (2017). The Role of Engineering Design in Technological and 21st Century Competencies Capacity Building: Comparative Case Study in the Middle East, Asia, and Europe. *Sustainability 2017, 9 (4), 520*.

Binkley, M., Erstad, O., Hermna, j., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). *Defining Twenty-First Century Skills.* Dordrecht: Springer.

Clarke, M. (2012). The Response of the Roman Catholic Church to the introduction of vocational education in Ireland, 1930-1942. *History of Education: Journal of the History of Education Society*(41:4), 477-493.

Construction Industry Federation (2017). *www.apprentices.ie*. Retrieved July 18th 2017 from http://apprentices.ie/service/electrician/

Coolahan, J. (1981). *Irish Education History and Structure.* Dublin: Institue of Public Administration.

Crockett, L., Jukes, I., & Churches, A. (2011). *Literacy is not enough: 21st-century fluencies for the digital age.* Kelowna, BC: Corwin.

Dam, R., & Siang, T. (2017). *www.interaction-design.org*. Retrieved August 22, 2017, from https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process

Darmody, M. and Smyth, E. (2005). *Gender and Subject Choice: Take-up of Technological Subjects in Second-Level Education.* Dublin: ESRI.

Department of Edcuation and Skills (2016). *Irelands National Skills Strategy 2025.* Dublin: The Stationary Office. Retrieved August 10, 2017, from https://www.education.ie/en/Publications/Policy-Reports/pub_national_skills_strategy_2025.pdf

Department of Education (1952). *Report of the Department of Education 1950-51.* Dublin: The Stationary Office. Retrieved August 22, 2017, from https://www.education.ie/en/Publications/Statistics/stats_statistical_report_1950_1951.pdf

Department of Education (1989a). *Materials Technology (Wood) Syllabus.* Dublin: The Stationary Office. Retrieved August 28, 2017, from http://www.curriculumonline.ie/getmedia/4d5e057a-d5f9-422b-87a3-9138ef15d9af/JCSEC17_Materails-wood-technology_syllabus.pdf

Department of Education (1989b). *Metalwork Syllabus.* Dublin: The Stationary Office. Retrieved August 28, 2017, from http://www.curriculumonline.ie/getmedia/afcbbe71-fb87-47da-ae47-1c406ff91583/JCSEC19_metalwork_syllabus.pdf

Department of Education (1989c). *The Junior Certificate Technical Graphic Syllabus.* Dublin: The Stationary Office. Retrieved August 28, 2017, from http://www.curriculumonline.ie/getmedia/5b5b40be-18fb-4e1e-8d1a-1cb2694cc1db/JCSEC26_technicalgraphics_syllabus.pdf

Department of Education. (1989d). *The Junior Certificate Technology Syllabus.* Dublin: The Stationary Office. Retrieved August 7, 2017, from http://www.curriculumonline.ie/getmedia/934299b8-d2d8-461e-8d80-cca9d96e656b/JCSEC27_technology_syllabus.pdf

Department of Education (1989). *The Junior Certificate Technology Syllabus.* Dublin: The Stationary Office.

Department of Education and Science (1999a). *Primary School Curriculum: Mathematics.* Dublin: The Stationary Office. Retrieved July 13, 2017, from http://www.curriculumonline.ie/getmedia/9df5f3c5-257b-471e-8d0f-f2cf059af941/PSEC02_Mathematics_Curriculum.pdf

Department of Education and Science (1999b). *Primary School Curriculum: Science.* Dublin: The Stationary Office. Retrieved July 18, 2017, from http://www.curriculumonline.ie/getmedia/346522bd-f9f6-49ce-9676-49b59fdb5505/PSEC03c_Science_Curriculum.pdf

Department of Education and Science. (1999c). *Primary School Curriculum: Visual Arts.* Dublin: The Stationary Office. Retrieved August 13, 2017, from http://www.curriculumonline.ie/getmedia/0e0ccff3-97c4-45c8-b813-e7c119a650c3/PSEC04A_Visual_Arts_Curriculum.pdf

Department of Education and Science (2004). *The Senior Cycle in Second-Level Schools.* Dublin: The Stationary Office. Retrieved July 12, 2017, from https://www.education.ie/en/Publications/Education-Reports/The-Senior-Cycle-in-Second-Level-Schools.pdf

Department of Education and Science (2006). *Press Event: Press release*. Retrieved August 24 2017 from https://www.education.ie/en/Press-Events/Press-Releases/2006-Press-Releases/PR06-11-30.html

Department of Education and Skills (2014). *The National Strategy on Education for Sustainable Development in Ireland, 2014 - 2020.* Dublin: The Stationary Office. Retrieved August 24, 2017, from https://www.education.ie/en/Publications/Policy-Reports/National-Strategy-on-Education-for-Sustainable-Development-in-Ireland-2014-2020.pdf

Department of Education and Skills (2015). *Framework for Junior Cycle 2015.* Dublin. Retrieved August 4, 2017, from https://www.education.ie/en/Publications/Policy-Reports/Framework-for-Junior-Cycle-2015.pdf

Department of Education and Skills (2016). *Action Plan for Education 2017.* Dublin: The Stationary Office. Retrieved July 28, 2017, from https://www.education.ie/en/Publications/Corporate-Reports/Strategy-Statement/Department-of-Education-and-Skills-Strategy-Statement-2016-2019.pdf

Department of Jobs, Enterprise and Innovation (n.d.). *DES Curriculum and Assessment Unit.* Retrieved August 22, 2017, from https://dbei.gov.ie/en/Consultations/Consultations-files/DES-Curriculum-and-Assessment-Unit.pdf

Education and Training Boards Ireland (2013). *Submission to Department of Education and Skills on The Future of Apprenticeship in Ireland.* Naas: Education and Training Boards Ireland (ETBI).

Griffin, P., Care, E., & McGaw, B. (2011). *Assessment and Teaching of 21st Century Skills.* Dordrecht: Springer.

Higher Education Authority (2017, March 1). Retrieved from http://hea.ie/assets/uploads/2017/07/New-Entrants-by-Institution-Gender-and-Field-of-Study-2016_17.xlsx, http://hea.ie/statistics-archive/

Hyland, A., & Milne, K. (1992). *Irish Educational Documents Volume* (Vol. II). Dublin: Church of Ireland College of Education.

I Wish (2017). *Female students' attitudes towards STEM*. Retrieved from http://www.iwish.ie/wp-content/uploads/2017/09/I-Wish-2017-Survey-FD.pdf

Irish National Teachers' Organisation (2013). Numeracy in the Primary School: A Discussion Paper. *Education Conference 2013*. Retrieved August 17, 2017 from : https://www.into.ie/ROI/NewsEvents/Conferences/EducationConsultativeConference/EducationConsultativeConference2013/Ed_Conf_2013_Discussion_Paper.pdf.

Jenkins, T. (2015). *Bringing Engineering Design to the Classroom*. Retrieved July 24, 2017 from www.teachingchannel.org/blog/2015/12/11/engineering-design/

Kolk, M. (2012). *Build 21st Century Skills with Design Thinking*. Retrieved August 13, 2017 from http://creativeeducator.tech4learning.com/2012/articles/Interview-Dr_Maureen_Carroll

Kwek, S. (2011). *Innovation in the Classroom: Design Thinking for 21st Century Learning.* Master's thesis, Univeristy of Stanford.

Leahy, K., & Phelan, P. (2014). A review of Technology Education in Ireland; a changing technological environment promoting design activity. *International Journal Of Technology And Design Education, 24*(4), 375–389.

Lewis, M., & Kellaghan, T. (1987). Vocationalism in Irish Second-Level Education. *The Irish journal of Education, 1*, 5-35.

McGarr, O., & Lynch, R. (2015). Monopolising the STEM agenda in second-level schools: exploring power relations and subject subcultures. *International Journal of Technology and Design Education, 27*(1), 51-62.

Morrison, J. S. (2006). Attributes of STEM Education. *TIES STEM Education Monograph Series*, 2.

Mulcahy, D. G. (1981). *Curriculum and Policy in Irish Post-Primary Education.* Dublin: Institute of Public Administration.

Mulcahy, W. (1942). *Rural Vocational Schools.* Master of Arts in Education dissertation, UCD.

National Council for Curriculum and Assessment (2004). *Board of Studies for the Provision of Technology Education in the Junior Cycle: Final Report.* Retrieved August 24, 2017 from http://ncca.ie/ga/Foilseach%C3%A1n/Tuarasc%C3%A1lacha/Review_of_Technology_Education_in_the_Junior_Cycle_Final_Report_of_the_Board_of_Studies.pdf

National Council for Curriculum and Assessment (2007). *ESRI research into the experiences of students in the third year of junior cycle and in transition to senior cycle: Summary and commentary.* Retrieved July 25, 2017 from http://www.igc.ie/download/1/Parents/Parents%20THE%20EXPERIENCES%20OF%20THIRD%20YEAR%20STUDENTS%20-%20N.C.C.A..pdf.

National Council for Curriculum and Assessment (2009a). *Aistear: the Early Childhood Curriculum Framework and the Primary School Curriculum Audit: Similarities and differences.* Dublin 2: National Council for Curriculum and Assessment.

National Council for Curriculum and Assessment (2009b). *Towards learning an overview of senior cycle education.* Dublin.

OECD (1965). *Investment in Education.* Dublin: The Stationary Office.

OECD (1969). *Reviews of national policies in education Ireland.* Dublin: The Stationary Office.

Smyth, E., Dunne, A., McCoy, S., & Darmod, M. (2006). *Pathways through the Junior Cycle: the Experience of Second Year Students.* Dublin: The Liffey Press.

State Examination Commision (2008a). *Technical Graphic Chief Examiners Report.* Retrieved July 10, 2017, from https://www.examinations.ie/archive/examiners_reports/cer_2008/JC_Technical_Graphics_2008.pdf

State Examination Commission (2008b). *Annual Report 2008.* Retrieved July 13, 2017, from https://www.examinations.ie/about-us/SEC_Annual_Report_08.pdf

State Examination Commission (2009a). *Annual Report 2009.* Retrieved July 13, 2017, from https://www.examinations.ie/about-us/SEC_AR_2009.pdf

State Examination Commission (2009b). *Materials Technology (Wood) Chief Examiner's Report.* Retrieved July 10, 2017, from https://www.examinations.ie/archive/examiners_reports/JC_Materials_Technology_Wood_2009.pdf

State Examination Commission (2009c). *Technology Chief Examiner's Report.* Retrieved July 10, 2017, from https://www.examinations.ie/archive/examiners_reports/JC_Technology_2009.pdf

State Examination Commission (2010b). *Annual Report 2010.* Retrieved July 13, 2017, from https://www.examinations.ie/about-us/2010_Annual_Report_English_Web_version.pdf

State Examination Commission (2010b). *Metalwork Chief Examiner's Report.* Retrieved July 10, 2017, from https://www.examinations.ie/archive/examiners_reports/JC_Metalwork_CER_2010.pdf

State Examination Commission (2011). *Annual Report 2011.* Retrieved July 13, 2017, from https://www.examinations.ie/about-us/SEC_Annual_Report_2011_Final_English_Version.pdf

State Examination Commission (2012). *Annual Report 2012.* Retrieved July 13, 2017, from https://www.examinations.ie/about-us/SEC_AR_2012_Final.pdf

State Examination Commission (2013). *Annual Report 2013.* Retrieved July 13, 2017, from https://www.examinations.ie/about-us/2013_Annual_Report.pdf

State Examination Commission (2014). *Annual Report 2014.* Retrieved July 13, 2017, from https://www.examinations.ie/misc-doc/EN-AU-30240294.pdf

Sterman, C. (2015). Teaching by Design: Design thinking is a problem-solving strategy that helps build students' 21st century skills. *Principal Special Supplement*, 2-5. Retrieved August 12, 2017 from https://www.naesp.org/sites/default/files/TechingByDesign_CCAC15.pdf.

The STEM Education Review Group (2016). *STEM Education in the Irish School System: A Report on Science, Technology, Engineering and Mathematics (STEM) Education.* Retrieved August 17, 2017, from https://www.education.ie/en/Publications/Education-Reports/STEM-Education-in-the-Irish-School-System.pdf

World Economic Forum (2016). *Executive Summary: The Future of Jobs and Skills.* Geneva: World Economic Forum. Retrieved July 24, 2017 from http://www3.weforum.org/docs/WEF_FOJ_Executive_Summary_Jobs.pdf.

NCCA