ENGINEERS IRELAND

Report of Task Force on Education of Mathematics and Science at Second Level

February 2010

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Preface

By Dr. Chris Horn

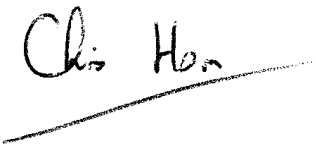
President of Engineers Ireland

I am delighted to introduce the Engineers Ireland Report on Education of Mathematics and Science at Second Level. The work arose from a continuing and growing concern over the annual results of Leaving Certificate examinations, combined with anecdotal evidence from some of our Members of a general demising competence in mathematics and science amongst school leavers.

Engineers Ireland has no formal role in the education of mathematics and science in our school system. We stand outside of the system, but observe and analyse. However we are more than willing to offer our support with our competencies, practical experience and our enthusiasm to both teachers and students alike. We make specific recommendations in this report for actions which we can undertake to help.

As President of Engineers Ireland, I would like to express my sincere appreciation and admiration to PJ Rudden, the Chair, and to all the members of the Taskforce, all of whom are listed in Appendix A. Many meetings, many interviews and many hours were devoted across the country over a six month period, pro bono, in service of the profession and, indeed, of Ireland. On behalf of Engineers Ireland, I would also like to thank the many individuals who willingly gave their time to our Taskforce, providing expert and wise counsel, analysis and insight: these reviewers and consultees are listed in Appendices A and C.

An appreciation of mathematics underpins not just engineering and innovation, but science and the humanities, business and the arts. In re-building our economy, all of us must rediscover the intense value of mathematics.



Executive Summary

Aim of Report

Engineers Ireland are concerned with the approach to the education of Mathematics and Science subjects at Second Level. This concern arises from the importance of these subjects and especially Mathematics to the engineering profession.

This report was commissioned to assess the current situation, to examine currently proposed curricula and teaching approach changes and to make recommendations for improvements both nationally and in what Engineers Ireland can do to assist and support.

What is Engineering?

Engineering is an exciting career which plays a fundamental part in our everyday lives. It is about solving problems using an inventive, creative and systematic approach, giving consideration to environmental, social and economic factors. Engineering increases the comfort and standard of living of all people on our planet in a sustainable way that will help our environment to survive and improve. Both Mathematics and Science are seen as essential subjects to support engineering knowledge and skills.

Current Position

Mathematics is seen as an essential everyday life skill and is also an essential component of the national drive towards a high value business and sustainable knowledge economy in Ireland required for national development and also to export our goods and services to international markets.

The teaching of Mathematics at Second Level has been evolving over the past few decades in Ireland though the evolution to Project Maths is probably the most radical change since the 1970s. There were many good teachers who used these techniques before they were labelled for the modern age but structurally it looked like Mathematics was losing the battle for the hearts and minds of current day pupils.

The current position is that approx 16% to 18% of students sitting the Leaving Certificate take Higher Level Mathematics as an examination subject. The low uptake at Leaving Certificate Level is mostly a direct result of the relatively low uptake of some 40% of students taking Higher Level Mathematics at Junior Certificate and only half of them (some 21%) gaining an A or a B at Higher Level. The NCCA are targeting future uptakes of 60% and 30% for Junior and Leaving Certificate Higher Level respectively which may be unrealistic at least in the short to medium term based on current realities.

With regard to the Science subjects the percentage uptake of Leaving Certificate students taking Biology, Physics, Chemistry and Applied Mathematics are 40%, 12%, 13% and 2.5% respectively. Biology is not considered further as it is by far the favourite Science subject particularly with girls.

Of the Physical Science subjects the most popular with girls is Chemistry where females represented some 55% of the entire Chemistry population at Leaving Certificate Level in 2009.

Much the same comments with regard to curriculum and teaching approach that apply to Mathematics also impact on Applied Mathematics in particular but in addition on Physics and Chemistry also. At the same time there was a welcome increase in CAO applications to Science subjects generally in 2009 counteracting a decline in applications for engineering courses with Civil Engineering and Construction courses worst affected due to the sudden downturn in the property and construction sectors of the economy.

Transition Year Potential

There is no doubt that Transition Year between Junior and Senior Cycle represents a generally untapped resource at Second Level.

Extraordinarily only about 25% of students nationally do Transition Year although it is now offered in some 70% of Second Level schools. Even where Transition Year is done the emphasis on 'work experience' and 'practical projects' tend towards the business area rather than science and technology. This is in our view an area where career guidance and Transition Year teachers need to focus more attention in future.

Current Drawbacks

The NCCA have correctly identified the principal current drawbacks with mathematical education in Ireland. These are the teaching of 'rote learning' rather than 'learning by understanding' and the anodyne teaching of the subject with little contextual links with the needs of the everyday world.

International Benchmarking

There is no room for complacency either in the international benchmarking of mathematical competence in Ireland. It was referenced in the NCCA International Review Report that Ireland was placed only mid range at 20th out of 40 countries surveyed whereas in terms of reading literacy we were rated 5th of out 39 countries surveyed. It was also noted that Ireland had comparatively few very high achievers and very low achievers.

New Approaches Under-Way

To meet this challenge the NCCA together with the Department of Education and Science have been assessing current deficiencies and designing new strategies and curricula to effect a step improvement in the mathematical competence at Primary and Second Level schools and even at Early Childhood. A new Early Childhood Framework 'Aistear' was introduced in 2009 and the Primary School curriculum was reformed at the start of the last decade. A review of Junior and Senior Cycle is now underway and a new initiative “Project Maths” has been launched.

Project Maths representing a whole new approach to Mathematics Education is currently being introduced at Junior and Senior Cycle Levels. A new curriculum is being designed split into strands which are being phased in over a 5 to 6 year period commencing in September 2010. The new Project Maths is currently being introduced in 24 Second Level schools around the country.

The five strands are Statistics/Probability, Geometry/Trigonometry, Number, Algebra and Functions. There is increased emphasis in the programme on Statistics and Probability and that's why this strand is being rolled out first.

In Project Maths there is an emphasis on understanding and interpretation of mathematical problems rather than rote learning. Problem solving and teamwork are promoted. Indeed the key skills which Project Maths is designed to promote (communication, information processing, working with others, being personally effective, critical and creative thinking) are all skills that need to be developed in the professional engineer. The difficulty with Project Maths however is likely to be the quantum leap required in the transitioning of teaching methods. Only about 20 to 25% of Second Level Mathematics teachers have a degree in the subject and the level of mathematical education is generally low in Ireland although it is understood that many more teachers have studied Mathematics to degree level but this degree may not be in 'Mathematics'.

The Teaching of Mathematics

In an effort to address the teaching issue NUI Galway set up a new BA four year course in Mathematics and Education two years ago. What makes it different from other Mathematics or Education courses is their subject specialisation in both Mathematics and Applied Mathematics, the focus on subject specific teaching and the integration with other learning through the power of computers. The University of Limerick opened its National Centre for Excellence in Mathematics and Science Teaching and Learning in June 2009 and also offer the same course in partnership with NUIG. NUI Maynooth offer a MSc in Mathematics and Education together with the University of Cambridge aimed at current teachers of Mathematics who have not studied the subject to degree level. Similarly DCU offers a BSc in Science and Mathematics Education while they have also introduced a PhD in the area of Science and Mathematics. These courses designed to equip graduates with the necessary skills to expertly teach Mathematics (and Science) as well as up-skilling existing teachers could prove to be excellent national scaffolding for the new 'Projects Maths' whether by e-learning out of NUIG or through the similar courses by at least one University in the Dublin and Cork regions.

With regard to Science subjects remarkably Ireland is unique among 21 European countries where Science is not compulsory at Junior Cycle. Also students in Irish schools receive a lower proportion of teaching time in Science compared to the EU or OECD average - 8% compared to an average of 12%. As in the case of Mathematics it has been reported that less than 30% of teachers who teach a Science subject actually have a degree in that subject. Lack of adequate laboratory facilities in many schools is a further drawback as is the tendency to cut out a minority Science subject when school budget cuts are implemented.

Information and Communications Technology (ICT) to be Employed More

It is recognised that the modern power of ICT can greatly enhance the visualisation and computation needed for Mathematics and Science subjects. ICT when available and used in appropriate contexts in education adds value in teaching and learning. Research has shown a positive correlation between the use of ICT and academic performance. The reported benefits are gains in student achievement, increased student motivation, improvements in students higher order thinking and problem solving abilities and the development of students ability to work collaboratively.

Challenges for Project Maths

The Project Maths approach is likely to represent a positive advance in mathematical competence in Ireland. It is however a long term process likely to take at least one generation to embed the necessary skills. It also represents an even greater challenge to the teachers than to the students. The roll out of Project Maths does not appear to be hugely well resourced as there are as yet in January 2010 no text books or sample question papers for subjects to be examined in the June 2010 Leaving Certificate. In addition the question of providing adequate teacher training and ongoing Continuous Professional Development is a further concern at a time of reducing public expenditure in education in Ireland.

Another area of obvious deficiency prior to the introduction of Project Maths appears to be the lack of continuity between Primary and Post Primary or Second Level education in Ireland. As there is not a consistent national assessment scheme at the end of Primary education there is a huge divergence in the mathematical competence of students in First Year of a typical Second Level school.

Some teachers of Mathematics at Second Level remark on the inability of First Year entrants being quite unable to multiply the single digit numbers ‘8 by 6’ without the aid of a calculator. The use of calculators is an area of divergent views among Primary and Second Level teachers and principals. While calculators have taken the tedium out of mundane calculations they are unfortunately part of the 'rote learning' syndrome of current educational practice in Ireland. They have also played a role in diminishing standards of mathematical understanding and literacy leading to mediocrity in Mathematics at higher levels of education.

PROPOSALS FOR PERFORMANCE IMPROVEMENT

Based on analysis of the current state of Mathematics and Science Education at Second Level Engineers Ireland make the following proposals for national performance improvement:

Proposal 1 – Support Project Maths and Ensure Adequate Resourcing

The advancement of national economic objectives requires a more holistic approach to the education of Mathematics and Science using the Project Maths model currently being introduced by the NCCA. However this new venture towards improved national mathematical competence needs better investment in terms of resource materials and CPD teacher training to expedite successful outcomes as it could take a full generation to embed it in our educational system. We support the proposal to give every Mathematics teacher 10 days of in-service CPD training within the phased rollout. Also a stronger focus on the new curriculum for Junior Cycle is needed as this is where the principal problem lies with Mathematics as well as in the Senior Cycle.

Proposal 2 – Make Science Compulsory at Junior Level

The importance of Science subjects to the future ‘knowledge economy’ is such that Science needs to be made a compulsory subject at Junior Cycle Level as is the case in the vast majority of EU countries. This needs to be complemented immediately by a stronger focus on Science and also Mathematics at Junior Cycle.

Proposal 3 – Ensure Maths Teachers are Adequately Qualified to Teach

The teaching of Mathematics at Second Level should require a degree or post graduate diploma in Mathematics and adequate education qualifications for all existing teachers in addition to new entrants. The current BA in NUIG in Mathematics and Education and MSc in Mathematics Education in NUIM should be extended by a combination of e-learning (from NUIG) and initiatives of similar courses in Dublin and Cork. This may require further resources, which could be achieved through potential collaboration with the National Centre for Excellence in Mathematics and Science Teaching & Learning in UL as well as other strategic partnerships. Similar courses in the Mathematics and Science Education area are also offered by NUI Maynooth and Dublin City University in the Dublin region. Existing teachers should be required to engage in accredited CPD courses approved by the Department of Education and Science and encouraged to avail of the many resources and support programmes offered by the NCE-MSTL. There is also the potential to equip engineers who desire a 'career change' with the necessary educational skills to teach Mathematics in a very contextual and practical way and in the meantime to act as "facilitators" which are current vacancies recently advertised by the NCCA.

Proposal 4 – Ensure Science Teachers are Adequately Qualified to Teach

The teaching of Science at Second Level should also require a degree or post graduate diploma in the relevant Science subject together with adequate teacher education qualifications. Similarly Chemistry, Physics and Applied Mathematics teachers at Second Level should have degrees in these respective fields.

Proposal 5 – Use the Power of ICT to Teach and Learn Better

The use of ICT and video needs to be significantly improved to assist and support the new Mathematics and Science curricula. This will aid the visualisation and understanding of the most abstract concepts. This also requires the provision of adequate CPD training for those many teachers with low IT literacy. In particular, as part of the 'innovation' drive to the 'smart economy' a key incentive should be the creation of inventories of ICT based systematic thinking and tools summarily described under the heading of TRIZ. There are also online aids to learning available which could also be assisted by Engineers Ireland (e.g. Reachateacher.ie).

Proposal 6 – Incentivise Teachers and Students

The improved teaching of Mathematics should be incentivised through the award of scholarships and prizes to "teachers of outstanding merit" in addition to the award winning students, e.g. Engineers Ireland should consider awarding an annual prize at the BT Young Scientist Exhibition for an outstanding project based on Project Maths.

Proposal 7 – Have Consistent Quality Tests at End of Primary

There needs to be a consistent national assessment test through continuous assessment or otherwise to determine the standards of mathematical competence at the end of Primary school as the lack of consistent standards in First Year Junior Cycle is endangering the necessary uplifting of standards at Junior Cycle.

Proposal 8 – Use Transition Year to Encourage Maths and Science

Transition Year should be more encouraged at Second Level and the percentage and scope of the mathematical content of Transition Year's work upgraded to make a most meaningful contribution to Project Maths and Science subjects. More project work in Mathematics Science and Technology should be encouraged during Transition Year.

Proposal 9 – Better Linkage Needed Between Primary and Second Level

There needs to be greater 'joined up' thinking between Primary and Second Level Mathematics and Science as currently there are insufficient linkages. The new common first year course for Project Maths needs a strong implementation focus to correct current deficiencies. Linkages must also extend to Third Level with particular emphasis between Third Level Engineering degrees, Higher Certificates from Institutes of Technology and Leaving Certificate. Both linkages need strong promotion from the NCCA and Universities Ireland/Institutes of Technology.

Proposal 10 – More Career Guidance Needed on STEM Careers

There appears to be a lack of appreciation in the Career Guidance Profession of the need to ensure high uptakes of good quality graduates in Science, Engineering and Technology courses and to support and encourage the national efforts to rebuild a smart economy and assist national recovery. One reason for this is that too few career guidance professional come from the Maths Science and Technology areas. The Career Guidance Profession should examine the situation further.

Proposal 11 – Overhaul and Integrate Applied Mathematics into New Approach

The Applied Mathematics syllabus requires an urgent overhaul in line with the Project Maths model. Applied Mathematics needs to be promoted as a practical example of how Mathematics is relevant to problem solving in Engineering, Science and other Technology courses. There is a need to increase the number of schools who offer this subject particularly in girl schools. The issue of adequate teacher resources and CPD needs to be addressed. Also consideration needs to be given to altering the name of this subject to Engineering Mathematics.

Proposal 12 – Implement 'Tax Breaks' for Teacher Retraining

The Government should examine the possibility of 'tax breaks' for Mathematics and Science teachers who register for full time retraining and CPD in NUI Galway, UL, NUI Maynooth, DCU or similarly approved specific courses in the subjects of Mathematics and Education. This will be a positive step towards the national 'smart economy'.

Proposal 13 – Ban Calculators at Primary and Junior Cycle Levels

The reliance on calculators in Early School interferes with the child's ability to appreciate numbers and appears to lead to a general decline in some aspects of numeracy. Thus their use should be banned or withdrawn by the Minister in Primary and Second levels up to and including Junior Certificate.

Proposal 14 – Better Resource Laboratories at Second Level

There needs to be continued resourcing at a significant level for the provision of Science laboratories in Second Level schools nationally. In addition the proper introduction of the new Project Maths will need new resource accommodation labs or libraries for ICT, video and other resources.

Proposal 15 – Appoint 'Head of Subject' in Each School

Second level schools should identify 'curriculum champions' in each school who would be 'Head of Maths' or 'Head of Science' and who would specialise in ensuring that all teachers in that area would be fully conversant with curriculum changes as they arise and lead in terms of teaching policy in that school for that subject.

Proposal 16 – Give More Teaching Time to Mathematics

The amount of classroom time allocated to the teaching of Mathematics at Primary and Second Level needs to be increased. In recent years the amount of time allocated to Mathematics has been reduced at these levels particularly at Junior Cycle due to an expanded curriculum. At least one class period a day should be allocated to the teaching of Mathematics at Second Level in each school.

Proposal 17 – Investigate Failure Rates at Ordinary Level Leaving Certificate Maths

There needs to be a thorough examination into the failure rates at Ordinary Level Leaving Certificate Mathematics as these high failure rates are having a serious impact on the quality of mathematical competency of those entering Level 6/7 institutions.

Proposal 18 – More Schools Need to do Higher Level Maths

There is a need to increase the number of schools that currently offer Higher Level Mathematics. Many schools are unable to offer this as only a minority of students wish to take Higher Level and schools cannot afford to designate a teacher to just a few students. This proposal will only work if we incentivise student interest and demand for Maths and Science through curriculum change and exciting new teaching methods.

ACTIONS

Having regard to our research to date Engineers Ireland commit to the following in terms of the assistance and support we can give to the better education of Mathematics and Science at Second Level:

Action 1

That Engineers Ireland as the authoritative voice of Irish Engineering and as a leading professional group in the 'knowledge economy' seek a voice in the NCCA in the future direction of curriculum change subjects relevant to our profession at Second Level i.e. Mathematics, Applied Mathematics, Physics and Chemistry and in implementation groups with this purpose.

Action 2

That Engineers Ireland offer award incentives to teachers to retrain and up-skill to meet the challenges of new syllabi in Mathematics and Science subjects. These incentives could take the form of sponsored scholarship schemes or alternative award schemes for 'outstanding merit' including the BT Young Scientist Awards.

Action 3

Due to the current downturn in the construction industry, advantage could be taken of retraining engineers as Mathematics and Science teachers. This is subject to them acquiring an acceptable post-graduate degree or diploma qualification in Education similar to the new NUIG, UL, DCU and NUIM Mathematics and Education degrees and support courses in DIT, CIT and WIT. Engineers Ireland must encourage and promote this development with the Teaching Council and NCCA and seek possible tax breaks for the retraining of personnel.

Action 4

Engineers Ireland need to awaken greater interest in Project Maths/Science at both Primary and Second Level by better integration into the STEPS programme to ensure more holistic and integrated learning towards Engineering and Science subjects and with particular regard to Transition Year teaching and students. The STEPS Programme should be re-examined and strengthened to help fulfil the Engineers Ireland recommendations in this report.

Action 5

Engineers Ireland should lead a greater use of the power of ICT to contextualise the teaching of Mathematics and Science at Primary and Second Level.

Action 6

Engineers Ireland should set-up on our new website a Wiki-Solution web page to assist students with problem solving in Mathematics and Applied Mathematics and link with other relevant sites.

Action 7

Engineers Ireland should consider setting up an Education Division to attract Third Level professors and lecturers in Mathematics, Science and Engineering to join and participate in greater numbers. We should also include Primary and Second Level teachers at meetings on a regional level to aid improved communication between teachers and engineers on a professional level. The essential continuity links between Primary and Second Level need to be emphasised in these regional 'conversations'.

Action 8

There needs to be more formal links between Engineers Ireland and Women in Technology and Science (WITS) to ensure greater gender integration in Mathematics, Science and Technology courses.

Action 9

The rising failure rates at Ordinary Level Leaving Certificate Mathematics must be urgently examined as it will seriously impact on the future standard of technicians (Level 6/7) in Ireland.

Action 10

There is a significant opportunity for interactions in Transition Year by Engineers Ireland. We must make it more practical with topical projects within the Project Maths, Science and Engineering fields. There are great future opportunities for Engineers Ireland to link with Second Level schools, Teacher Associations/Unions and Industry to assist further the development of the 'smart economy'.

Terms of Reference of Task Force

Objective

Our task was to identify helpful and tangible initiatives which Engineers Ireland can take to improve the quality and uptake of Higher Level Mathematics and Science leading to high quality intake into our Engineering Schools.

Terms of Reference

1. To assess the current statistical trends of take-up and success in each subject at Junior and Leaving Certificate (Science to include Applied Mathematics, Physics, and Chemistry).
2 To document and comment on current proposals by the NCCA with respect to Mathematics and Science (including Project Maths).
3. To comment on the current and proposed teaching methods in both Junior and Leaving Certificate subjects and what we can learn from the innovations in other subjects.
4. To assess and recommend how to enhance the quality of teaching of both subjects.
5. To propose a series of initiatives by Engineers Ireland to improve the education of Mathematics and Science at Second Level.

List of Abbreviations

CPD	Continuous Professional Development
DCU	Dublin City University
DES	Department of Education & Science
DIT	Dublin Institute of Technology
EGFSN	Expert Group on Future Skills Needs
EI	Engineers Ireland
ERC	Education Research Centre
IBEC	Irish Business and Employers Confederation
ICT	Information and Communications Technology
NAMA	National Assessment of Mathematical Achievement
NAPD	National Association of Principals and Deputy Principals
NCCA	National Council for Curriculum Assessment
NCE-MSTL	National Centre for Excellence in Mathematics and Science Teaching and Learning
NUIG	National University of Ireland Galway
NUIM	National University of Ireland Maynooth
OECD	Organisation for Economic Co-operation and Development
PDGE	Post Graduate Diploma in Education
PISA	Programme for International Student Assessment
RIA	Royal Irish Academy
SET	Science, Engineering & Technology
SPCD	St. Patricks College Drumcondra
STEM	Science Technology Engineering & Mathematics
STI	Science Technology & Innovation
TCD	Trinity College Dublin
UL	University of Limerick
WITS	Women in Technology and Science

Chapter 1 Introduction

1.1 Role of Engineers

Engineers are responsible for a wide range of activities essential to everyday life from the water supply in our homes, offices and schools to electricity and transport systems, the processing of our food, the creation of new human organs through biomedical engineering and the development of the 'microchip' in our personal computers or iPods. Thus, since the learning of Mathematics and Science is essential to modern day living it needs to be seen as more of an essential life skill.

Engineers Ireland (EI) is the representative voice of the engineering profession on the island of Ireland. We represent some 24,500 engineers and engineering students mainly in the civil, structural, mechanical, electrical, electronic, IT, manufacturing, industrial, agricultural, food, environmental, energy, building services, fire, communications, chemical, process and biomedical fields. The successful completion of Higher Level Mathematics at Leaving Certificate is a matriculation requirement of engineering Universities in Ireland. Mathematics and Science are essential components of scientific and engineering learning in our Universities and Institutes of Technology. Thus, our great concern in the gradually falling numbers of those achieving honours grades at Leaving Certificate Level at a critical time in our national history.

Apart from the everyday needs of consumers and business organisations, advanced Mathematics is widely used often in unseen and unadvertised ways. The Mathematics of error-correcting codes is applied to CD players and to computers. The stunning pictures of far away planets sent by Voyager II and Hubble could not be seen without Mathematics. In ecology Mathematics is used when studying the laws of population and climate change. Statistics is not only used for evaluation of business trends but is essential in medicine for analysing the cause of illnesses. Thus Mathematics is very often involved in life and death.

1.2 Need for Innovation and Enterprise

Ireland like the rest of the world is currently going through difficult economic times. In recent years what was previously a booming economy has seen growth dramatically reduced due to falling demand for property coupled with a banking/credit crisis. This has impacted severely on the engineering profession particularly the construction sector. Employment in engineering is falling as a result and redundant engineers are forced to emigrate. While the Government have taken steps to rectify the economy and to restore national and international confidence, the current climate poses an even greater need to evaluate and address key issues in Mathematics and Science education.

Greater numbers of engineering graduates were emerging from our Higher Education institutions during the period of high economic growth. In recent years, however, a progressive decrease in the demand for some engineering courses has caused the entry points for Third Level colleges to fall in both Universities and Institutes of Technology. At a time when Ireland is striving to recover from a worldwide recession we are also trying to up-skill our research in Innovation and Enterprise to grow a more efficient and environmentally sustainable economy[1].

1.3 Need for Change

Key to this future growth will be the need to maintain a 'world class' engineering profession in terms of industry skills and education for the future. There has been growing concern also over the past 5 to 10 years of the falling off in numbers of Second Level students going into both Engineering and Science courses at Third Level, particularly in Physics, Chemistry and Applied Mathematics. The number of graduates with a high level of mathematical competence is lower than a number of high achieving Organisation for Economic Co-operation and Development (OECD) countries although we appear middle ranked in this respect[2].

Genuine concerns also exist that relatively low student numbers in Higher Level Mathematics and Science subjects will have a detrimental impact on efforts to attract research and development (R&D) and build a knowledge economy. Indeed, the strategy document 'Building Ireland's Smart Economy: A Framework for Sustainable Economic Renewal (2008) recognises that science-based technology forms one of the cornerstones of the economy and that utilising the knowledge, skills and creativity of people is central to developing innovation and ideas[3]. It needs to be clarified here that our concern with the Science subjects (Physics, Chemistry & Applied Maths) is mainly due to their varying 'mathematical content' which may be acting as a disincentive to students entering Science or Engineering courses.

Engineers Ireland are concerned at the extent to which 'rote learning' is a teaching mechanism at Second Level for mathematical subjects rather than 'learning by understanding'. This concern is shared by other professions who require a high standard of competency and by the Minister for Education and Science.

Ireland's relative low literacy in Mathematics was recognised in the mid 1990's at both academic and industrial level. The Department of Education and Science (DES) asked the National Council for Curriculum and Assessment (NCCA) in 2005 to bring forward new proposals to deal with the matter. Various reports and consultations took place resulting in the introduction in 2008 of a new Project Maths curriculum, teaching and assessment. At the same time, it is realised that neither Mathematics nor Science subjects can be successfully taught in isolation. They are part of a needed integrated learning process with significant linkages to other subjects like language, art and indeed music.

1.4 Task Force Objectives

Probably no other profession is as impacted by the quality of education in both Mathematics and Science as the engineering profession. Therefore in September 2009 Engineers Ireland decided to set up a Task Force on the Education of Mathematics and Science. The Task Force members are listed in Appendix A together with Peer Reviewers and Consultees of the Report drawn from both Second and Third level education. The objectives of the Task Force were three-fold as follows:

1. To clarify and confirm the current position with regard to Mathematics and Science performance nationally in terms of policy and programme.

2. To assess the proposals by the NCCA for curriculum change including the new Project Maths course launched in 24 schools in September 2008 (see Appendix B).

3. To make recommendations to the Executive and Council of Engineers Ireland regarding how we can assist, support and incentivise teachers and students to work towards better performance in Mathematics and Science subjects as preparation for our engineering and technology schools.

1.5 Outline of Report

Chapter 2 of this Report outlines the current position of Mathematics and Science throughout the Irish educational system from a statistical perspective.

Chapter 3 offers an insight into the Mathematics and Science curricula at Primary, Junior and Senior Cycle Level. Current challenges associated with the aforementioned curricula are discussed in this section of the report together with recent initiatives devised to address these challenges.

Chapter 4 outlines suggested proposals to improve performance levels in Mathematics and Science at all levels of the educational system.

Chapter 5 lists Actions now proposed by Engineers Ireland to support the better education of Mathematics and Science at Second Level.

It should be noted that this report does not consider Science subjects to the same degree as Mathematics. The reference to “Science subjects” refer to the subjects of Applied Mathematics, Physics and Chemistry all of which contain varying degrees of mathematical complexity which tend to discourage student participation.

Chapter 2 Current Position

2.1 Introduction

High levels of mathematical and science ability is not only a requirement for the Engineering and Science industries but for general business and financial enterprise. Even at general consumer level a rudimentary knowledge of these subjects is required. Currently Ireland is ranked mid-table in terms of mathematical and science proficiency in the OECD league. The latest OECD Programme for International Student Assessment (PISA), 2006, of fifteen year old students ranked the mathematical and science proficiency of Irish students at 16th and 14th respectively amongst 30 OECD countries[4]. Our proficiency levels in these subjects are crucial to the development of a knowledge economy as well as our research and development base. It is imperative that Ireland strives to match the standards set by countries leading the OECD PISA table for mathematical performance to develop a world class educational system. In doing so Ireland will be in prime position to compete for high level Science, Technology and Innovation (STI) investment, thus assisting the regeneration of our struggling economy. Currently Finland, South Korea, Netherlands, Switzerland and Canada occupy the leading positions of the OECD Mathematics proficiency table. Turkey and Mexico occupy the last two positions. This section of the report examines our current status at Primary and Second Level identifying problematic areas where significant improvement is required.

2.2 Primary Cycle

The current Mathematics Primary Level curriculum was implemented in the 2001-2002 academic year. Currently there is no formal assessment of Mathematics, Science or any other subject at Primary Level. There are however two standardised tests used by teachers to determine the mathematical proficiency of Primary students. These mandatory tests are known as the Drumcondra and Sigma-T tests (schools free to choose whichever test they wish to use). The results of these tests and the test papers themselves are not made available to the general public. They are merely used by teachers to ascertain the competency levels of pupils and to highlight the strengths and weaknesses of a class. Results of these tests must be reported to parents at two points in the child's Primary school career.

In an effort to determine the current state of Mathematics in Primary schools and the mathematical proficiency of Primary Level students the Educational Research Centre (ERC) carried out a National Assessment of Mathematics Achievement (NAMA) in 2004[5]. The assessment was conducted in a similar fashion to one previous, 1999, so that results could be compared. The target population for NAMA 2004 included all pupils in 4th class in Irish Primary schools with the exception of pupils attending private schools, special schools or special classes in ordinary schools. In total 130 schools participated in the assessment with a total of 4171 students surveyed. The assessment focused on the strands Number, Algebra, Shape and Space, Measures and Data which form the basis of the Primary Level Mathematics curriculum.

The results of this assessment indicated that there had been no significant improvement in the mathematical ability of 4th class students between the years 1999 and 2004. The mean

score for the assessment in 1999 was 250 scale score points and for 2004, 250.8. The difference between these scores was deemed not statistically significant, indicating no change in overall performance between 1999 and 2004. This is despite the fact that a new curriculum was implemented in 2002. It is however appreciated that as just two years had passed since implementation of the new curriculum more time may be required before significant improvement become evident. For this reason it is important that a further assessment be carried out in the near future to determine the latest curriculum's true impact.

The mean percentage scores for each Primary Level Mathematics strand for the years 1999 and 2004 can be seen in Table 1.

Table 1 - Mean % Scores on Strands, 1999 and 2004

Strand	1999 Mean %	2004 Mean %
Number	57.4	56.7
Algebra	58.3	61.0
Shape & Space	50.8	55.7
Measures	54.1	54.0
Data	66.0	71.3

From the results it is evident that students achieved the highest score in both years for the strand Data. The only significant difference evident between the years was witnessed for the strands Shape & Space & Data which saw an increased score of approximately 5%.

Also assessed were the key mathematical skills; Understanding/Recalling, Implementing, Reasoning, Integrating/Connecting and Applying/Problem Solving. The percentage correct scores for these skills in the years 1999 and 2004 are presented in Table 2.

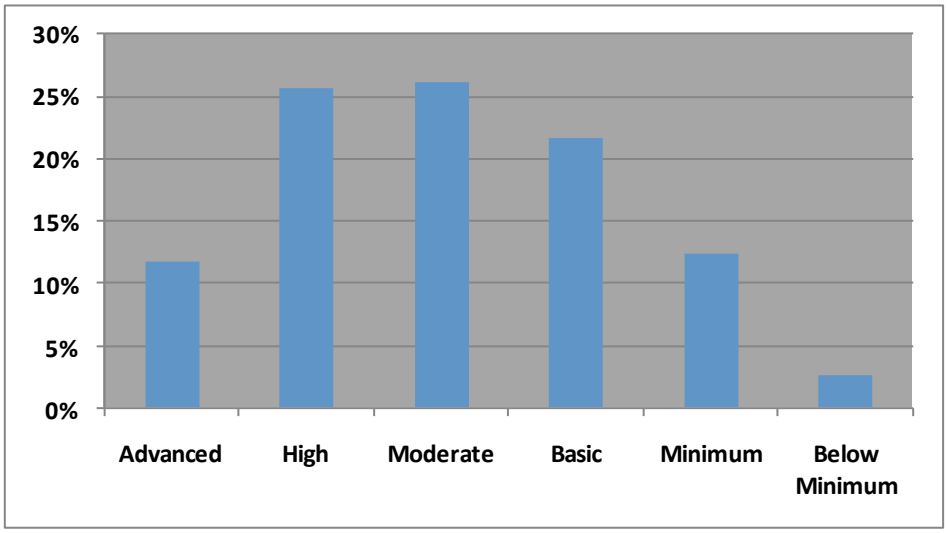
Table 2 - Mean % Score on Mathematics Skills, 1999 and 2004

Skills	1999 Mean %	2004 Mean %
Understanding & Recalling	61.9	63.8
Implementing	58.8	59.4
Reasoning	56.8	60.7
Integrating & Connecting	53.2	55.0
Applying & Problem Solving	50.5	49.0

These results indicate a significant increase for one skill, 'reasoning', which witnessed an increase of 3.9% between 1999 and 2004. The skills 'applying and problem solving' decreased by 1.5% however there were no significant differences evident for the remaining skills. The relatively low 'problem solving' ability of Irish school children has been noted as being a major area of concern in a number of reports over the past few years. The American Chamber of Commerce Ireland representing many of our largest multinational employers (Intel, HP, Wyeth etc) only recently, on January 5th 2010, condemned the Irish education system and in particular the problem solving, creative and innovative skills of Irish students. It is an area of particular concern[6]. Similar comments were made at the Farmleigh Conference on the Irish Economy in 2009 by international industrial leaders, some of Irish extraction.

Students were also measured on a mathematical proficiency scale in NAMA 2004 and results for this are illustrated in Figure 1.

Figure 1 - % of Pupils at Each Proficiency Level



In 2004 the majority of students were rated as having a moderate or high level of mathematic proficiency. 11.7% were considered to be at an advanced level while almost 15% were described as possessing a minimum or below minimum level.

The assessment also focused on gender. Although males scored slightly higher there was no discernable difference evident between males and females in their overall mean scores. However it was noted that a greater percentage of males (14.8%) than females (8%) performed at an advanced level while 29.8% of females performed at a moderate level compared to 22.9% of males. The assessment found 4th class males to be more confident in their mathematical ability. Females it was found maintained higher levels of enjoyment of the subject suggesting that the 'enjoyment factor' had no influence on achievement.

As part of the assessment inspectors were issued a questionnaire in order to voice their concerns in relation to Primary Level Mathematics. The results of this indicated that inspectors were least satisfied with the teaching of the Data and Algebra strands while 'reasoning', 'applying' and 'problem solving' were identified as the skills in most need of attention.

2.3 Junior Cycle

Junior Certificate Mathematics comprises a three year course designed to equip students with the Mathematical knowledge and skills required for the challenges as set by the Leaving Certificate course. It is at this point we must strive to embed high levels of mathematical competency and interest in our students. Improving Mathematics at this level will have a 'knock on' effect and lead to increased numbers taking the Higher Level paper at Leaving Certificate. The nine year average for students sitting the Mathematics exam is 98.1%, a positive result. The current syllabus was introduced in 2000 and first examined in 2003[7]. Engineers Ireland welcome the intentions of the 2000 Junior Cycle Curriculum with regard to teaching methodology: the emphasis on teaching for understanding, the use of "active teaching" methods, the focus on appreciation and enjoyment, and the stress on

communicating with regard to Mathematics. It is unclear however if these intentions are being fully embedded in the Irish Education system. Junior Certificate Mathematics is currently examined at Higher, Ordinary and Foundation Level.

Mathematics

Figure 2 - % Uptake of JC Mathematics by Level

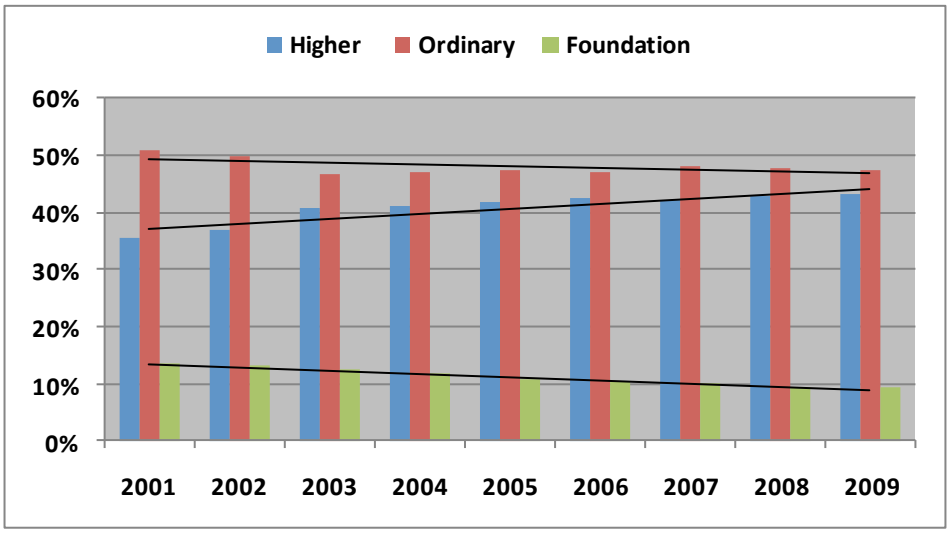


Figure 2 illustrates the percentage of students sitting Junior Certificate Mathematics by Level. The introduction of the new syllabus in 2000 witnessed a significant increase in the percentage of students taking the Higher Level paper. In 2009 43.1% of Junior Certificate students studying Mathematics sat the Higher Level paper, a 4.6% improvement on 2002 the final year the previous syllabus was examined. However this figure still falls someway short of the NCCA established target of 60% at Junior Certificate Level. This trend is also reflected in the numbers taking the Foundation Level paper as there was a 3.2% decrease in the percentage of students sitting this exam between 2003 and 2008. 2009 however saw a relatively low increase.

Figure 3 - % Breakdown of JC Higher Level Mathematics Results

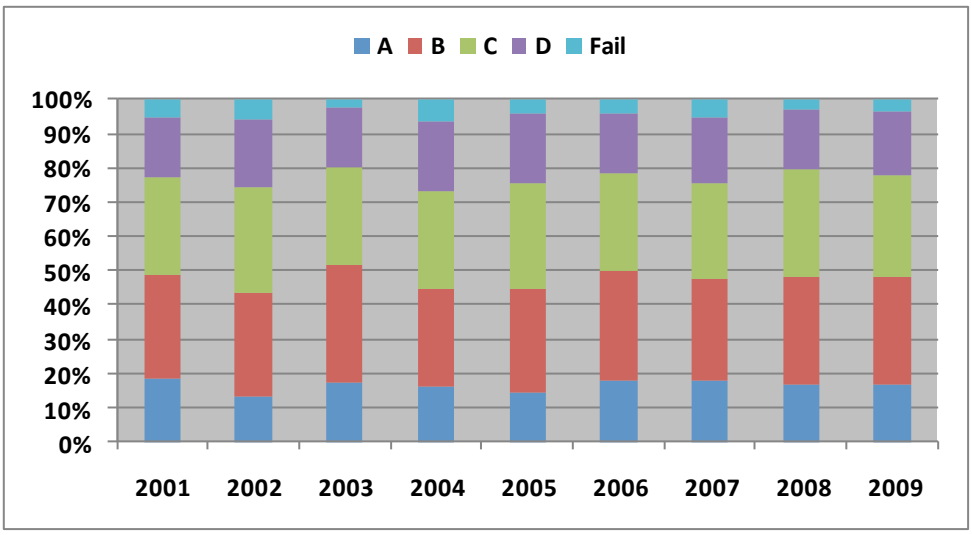


Figure 3 illustrates the % breakdown of results for Higher Level Junior Certificate Mathematics. The average failure rate since 2003 has been 4.2%. This suggests that the failure rate has decreased since the introduction of the current syllabus despite the fact a greater percentage of the Mathematics population have sat the Higher Level paper.

The percentage of students receiving honours has fluctuated over the past nine years with no significant change evident. In 2009 77.6% of those who sat the Higher Level paper received an honours grade representing approximately 33.5% of the entire Mathematics cohort. 20.7% of the cohort received a high honours grade (A or B) at Higher Level. These high achieving students are the very people that must be encouraged to take Higher Level Mathematics at Senior Cycle given the fact they have displayed an aptitude for the subject and demonstrated the desire to tackle a Higher Level Mathematics paper. In 2009 just 16.2% sat the Leaving Certificate Higher Level paper suggesting a small minority of students who are capable are simply opting out. In fact at present nearly two thirds of Higher Level students at Junior Cert drop to Ordinary Level in 5th and 6th year[8]. It must be ensured that any student capable of studying at Higher Level is encouraged, supported, and given every opportunity to do so. Furthermore we must increase the numbers taking the Higher Level paper from 40% to that of the NCCA target (60%) at Junior Certificate and in doing so increase the number of students achieving high honours at this stage. This will ensure greater numbers and a more mathematically proficient stream of students are fed into Senior Cycle. **Improving the current situation at Junior Certificate Level will ensure increased uptakes at Higher Level and better results at Leaving Certificate.**

Science

The Junior Certificate Science syllabus contains three subject areas; Physics, Chemistry and Biology. Junior Certificate Science provides a suitable preparation (but is not a requirement) for the study of one or more Science subjects at Senior Level. The latest syllabus was introduced in 2003 and first examined in 2006[9]. Junior Certificate Science is examined at Higher and Ordinary Level. There are two assessment methods; coursework (35% of the marks) and an examination paper (65% of marks)[10]. Statistics for the past nine years show that on average 85.6% of the cohort sit a Junior Certificate Science paper although it is not a compulsory subject.

Figure 4 - % Uptake of JC Science by Level

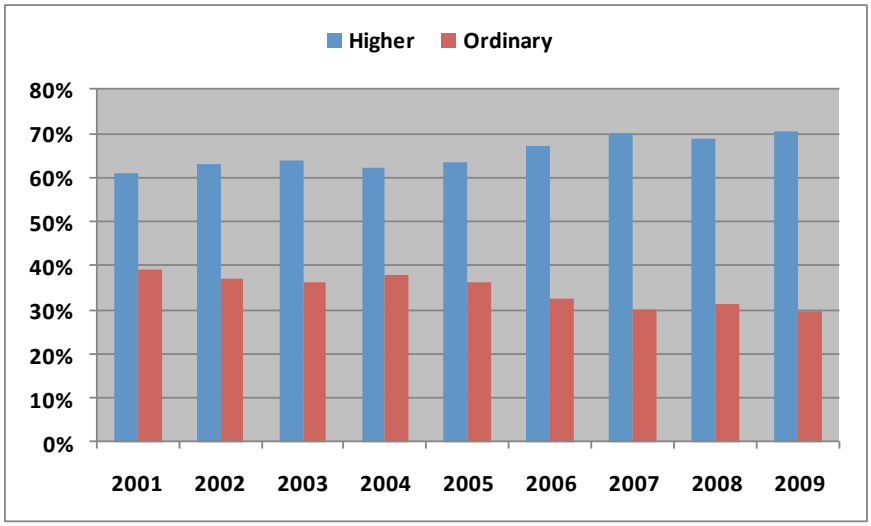


Figure 4 illustrates the percentage of students sitting Junior Certificate Science by level. Since 2006, first examination of the current syllabus, the percentage of students that have sat the Higher Level paper has increased. In 2005 63.7% of Science students sat the Higher Level examination. The introduction of the new syllabus appears to have positively influenced Science at Junior Certificate as the uptake of the Higher Level paper increased to 70.1% in 2007, a rise of 6.4% on the previous year. While 2008 witnessed a relatively low decrease in Higher Level examinations 2009 saw levels restored to that of 2007 as 70.6% of the Science population were examined at Higher Level.

In relation to the impact the chosen level of study has on student performance in Science at Junior Certificate Level the PISA 2006 analysis offers some valuable insights. It reports that Higher Level students obtained a mean PISA Science score of 550.9, far higher than the 441.1 obtained by students who took Ordinary Level. The top score recorded for Science in the PISA study went to Finland with a mean score of 563.3[11].

Figure 5 - % Breakdown of JC Higher Level Science Results

2006-2009 based on results of new syllabus only

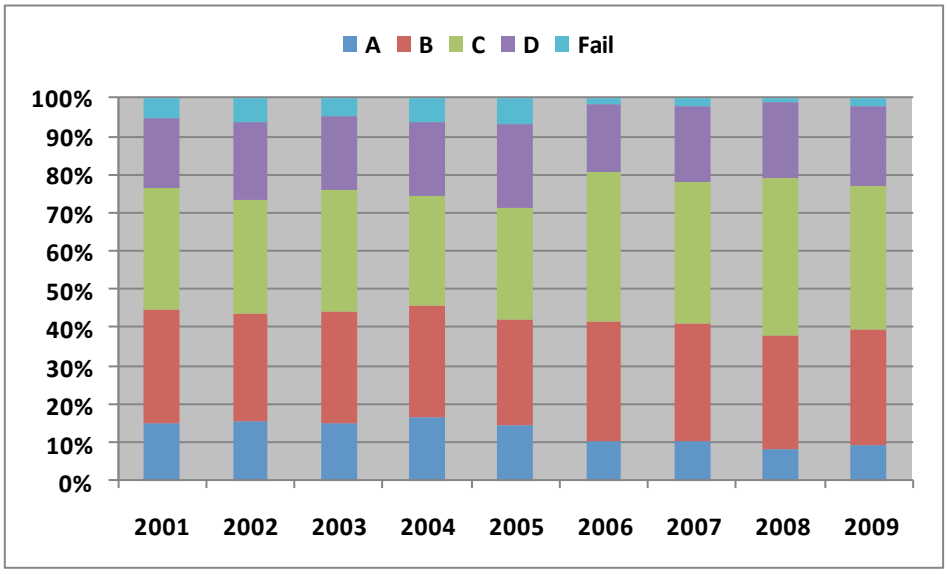


Figure 5 illustrates the percentage breakdown of results for Higher Level Junior Certificate Science. The new syllabus examined for the first time in 2006 witnessed a decrease in the failure rate of 5.4% on the year previous, a standard which has since been maintained. The percentage of students achieving honours has also increased however this masks the fact that the percentage of A Level students has decreased. This however should not be seen as a failure as students are now asked to think independently and 'rote learning' no longer guarantees an A grade. In 2008 8.1% of students achieved an A grade, a desirable level of achievement for A grades. This is a decline of 6.4% on 2005 Levels, the year in which the previous syllabus was last examined.

2.4 Senior Cycle

Mathematics

Despite not being a compulsory Leaving Certificate subject statistics show that over the past nine years on average 91% of the cohort have sat a Leaving Certificate Mathematics exam.

This is in part due to Mathematics being a matriculation requirement for the vast majority of Third Level Institutions. Leaving Certificate Mathematics is currently examined at three levels (Higher, Ordinary and Foundation). The current Higher and Ordinary syllabi were introduced in 1992. The Foundation Level syllabus was introduced in 1995 and first examined in 1997[12].

Figure 6 - % Uptake of LC Mathematics by Level

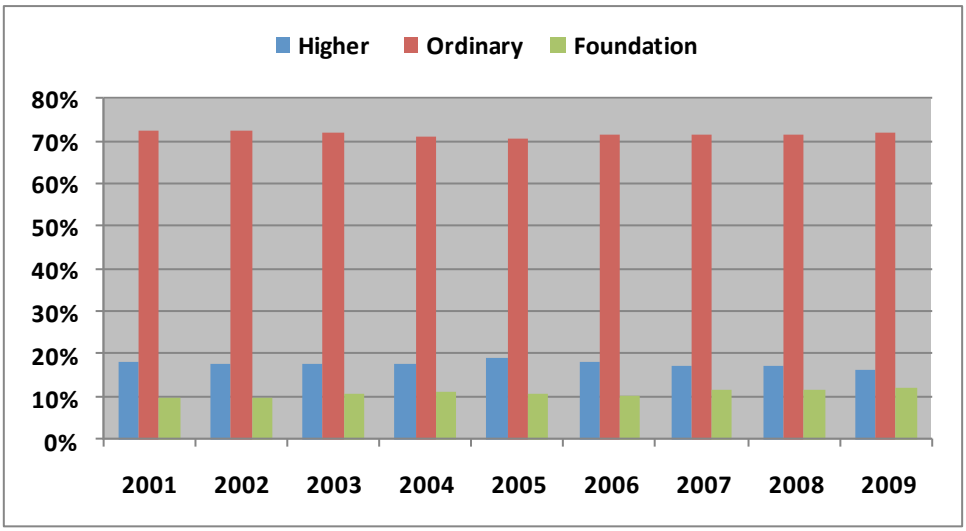


Figure 6 illustrates the percentage of students that have sat Leaving Certificate Mathematics at Higher, Ordinary and Foundation Level from 2001-2009. On analysis of this graph it is evident that the majority of students in Senior Cycle Level study Mathematics at Ordinary Level. The percentage of students sitting Higher Level Mathematics peaked in 2005 at 18.9%. Since 2005 there has been a steady decline in the numbers. In 2009 just 16.2% of Leaving Certificate Mathematics students sat the Higher Level paper, representing a 2.7% drop since 2005. The percentage of students studying Foundation Level Mathematics increased from 9.5% in 2001 to 11.0% in 2004. 2005 saw a slight decrease however the numbers have since increased peaking at 12.0% in 2009. **This statistic along with the drop in numbers tackling the Higher Level paper, suggest an overall decline in the level at which students are studying Mathematics.**

Figure 7 - % Uptake of LC Higher Level Mathematics 1993-2009

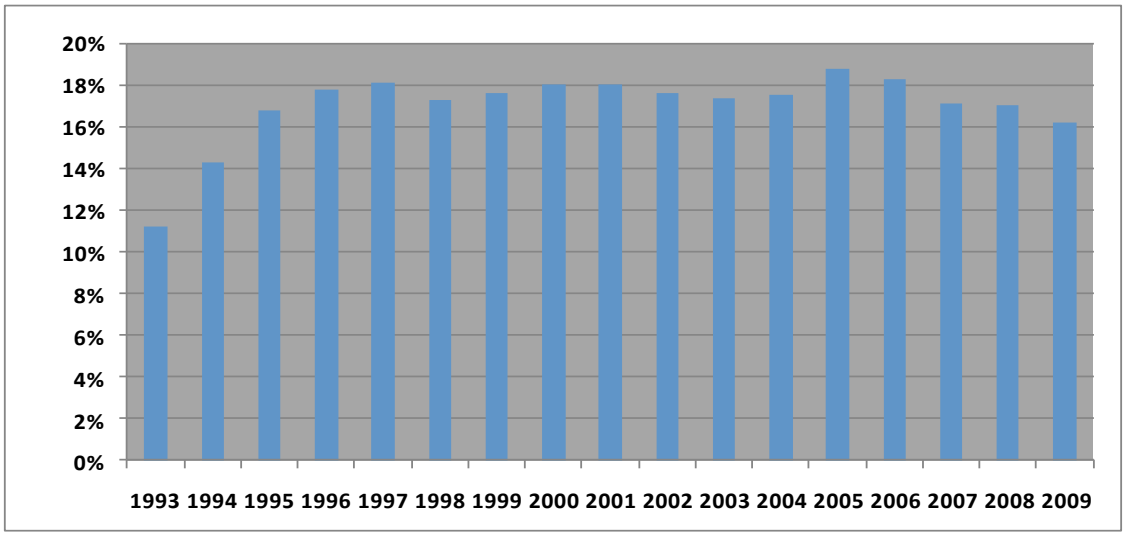


Figure 7 illustrates the percentage of students that have sat Leaving Certificate Higher Level Mathematics since 1993. When the current Higher Level Mathematics syllabus was introduced in 1992 the ultimate aim was to increase the uptake to 20-25% of the cohort. The initial target was in fact to have a ratio of 20-25%:50-60%:20-25%[13] at Higher, Ordinary and Foundation Level respectively. The ratio currently is in the region of 16%:72%:12%. Both the Higher and Foundation Level numbers have over the past 16 years fallen well short of their intended targets. On introduction of the syllabus there was a significant increase in Higher Level participants. In fact there was an increase of 6.9% between 1993 and 1997. However since 1997 there has been no significant increase while in recent years the numbers have declined.

The numbers taking the Higher Level paper must be vastly improved on. There have been numerous suggestions as to why targets are not being met, for example an over-crowded and non-interesting curriculum, 'rote' learning and a lack of teacher training and support. It has also been suggested that some schools are unable to offer Higher Level Mathematics to students as only a minority of them wish to take it. Schools therefore cannot afford to designate a teacher to just a small group of students hindering their ability and future opportunities at Third Level.

There have also been calls to reintroduce 'bonus points' for Honours Mathematics at Leaving Certificate level as incentives to students to spend more time at the subject. There is however significant evidence that 'bonus points' reintroduced in this way will have no real educational benefit as the problem is a great deal more complex and requires fundamental changes to curriculum and teaching methodologies[14].

Figure 8 - % Uptake of LC Higher Level Mathematics by Gender

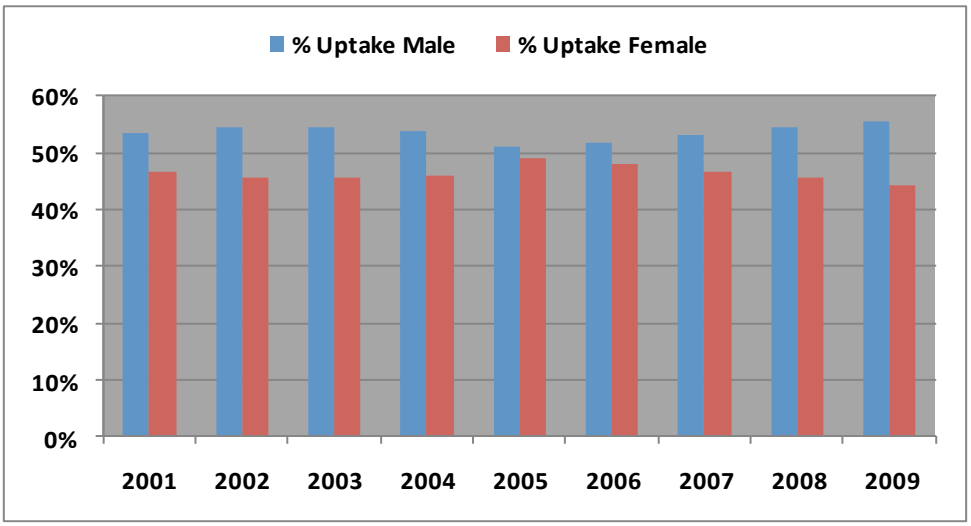


Figure 8 illustrates the percentage breakdown of males and females taking Higher Level Mathematics. A relatively small gender difference is evident as the majority of students taking the Higher Level paper are male, a fact which mirrors international trends. In 2009 56% of the Higher Level Mathematics population were male.

Figure 9 - % Breakdown of LC Higher Level Mathematics Results

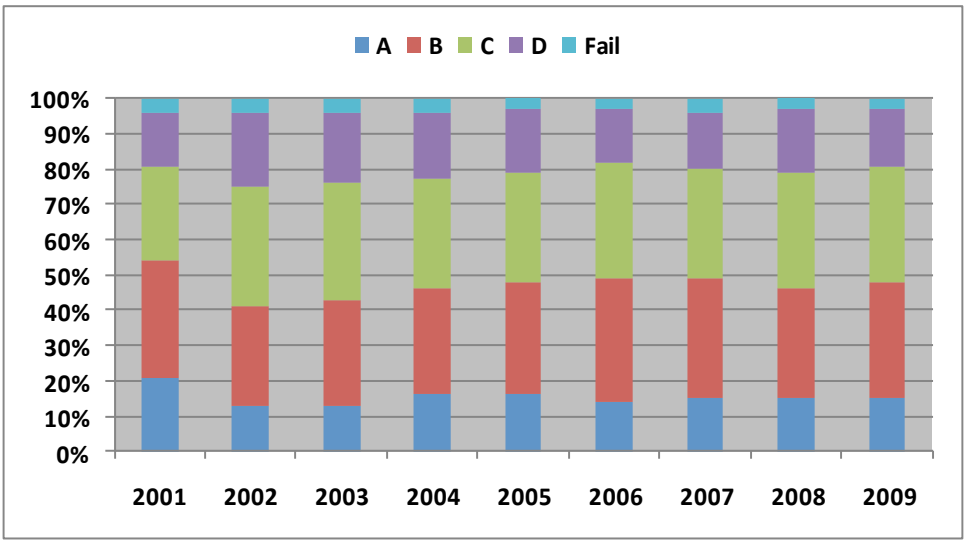


Figure 9 illustrates the % breakdown of results at Higher Level Mathematics. Throughout Ireland a minimum C3 grade in Higher Level Mathematics is a matriculation requirement for the vast majority of Level 8 Engineering courses. In 2009 81% of students who sat the Higher Level Mathematics examination achieved a C3 or better while 15% achieved an A grade. The average failure rate since 2001 is 3.8%.

In general males appear to achieve a higher percentage of A grades when taking the Higher Level paper. However females generally achieve a higher percentage of honour grades (A,B,C's) while a lower failure rate can also be attributed to the latter sex.

In order to proceed into a Level 6/7 Engineering and Technology course or indeed a Level 8 Science course students must achieve at the very least a passing grade in Ordinary Level Mathematics. **In 2008 approximately 5,000 (10% of the Mathematics cohort) students did not achieve a D grade in Leaving Certificate Mathematics with the failure rate of the Ordinary Level exam reaching 12%**[15]. This failure rate which has been consistently high over the past number of years is limiting the educational and employment prospects of many young people. It is contributing to the general demise of Mathematics at Level 6/7 (certificate and diploma) and will no doubt impact on the number of technicians available in Ireland in years to come.

The main reason for such a high failure rate at Ordinary Level can be attributed to the fact that Foundation Level Mathematics is not recognised by Third Level Institutions. This places undue pressure on many students to take the Ordinary Level paper when the Foundation paper may be more suitable to their ability and needs. Students taking Ordinary Level when not ready for the abstract concepts it contains fall back on rote learning. This reinforces the 'rote' culture of both learning and teaching in many Irish classrooms. **If Foundation level qualifications were recognised for entry to courses (for which they are appropriate!) then Ordinary level might be taught more meaningfully (to a higher-achieving cohort of students) and might function better in serving Science and Technology courses.**

Physical Sciences

The Physical Science Leaving Certificate subjects consist of Physics, Chemistry and Applied Mathematics. It should be noted that a Science subject is not compulsory for either Junior or Leaving Certificate although one or more science subjects may be required for matriculation purposes.

Figure 10 - % of LC Cohort Sitting Physics, Chemistry, Applied Mathematics, Geography and Biology

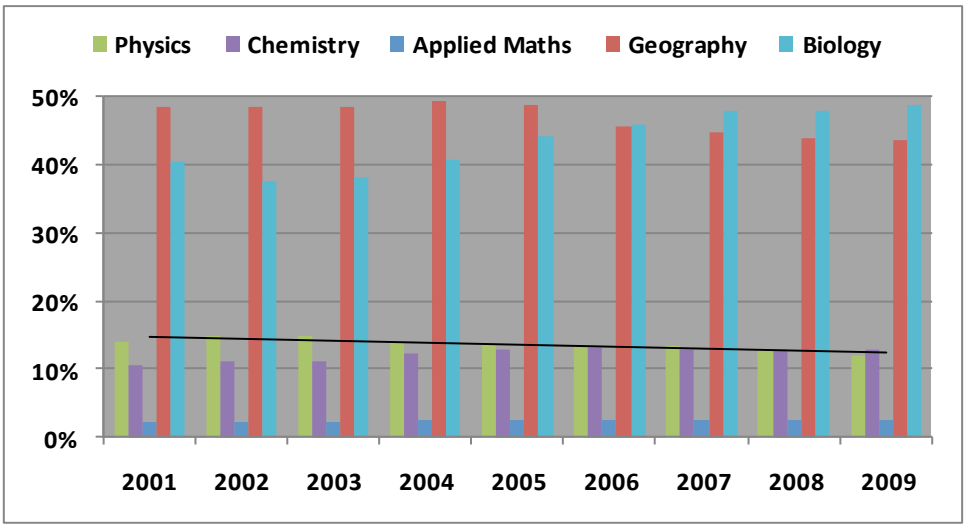


Figure 10 illustrates the percentage of the Leaving Certificate cohort that have sat a Physical Science examination in the years 2001-2009. It is evident from this graph that the numbers taking these optional subjects are extremely low especially when compared to more "attractive" subjects such as Geography and Biology. Applied Mathematics in particular is failing to attract students. In 2009 only 2.5% of the Leaving Certificate cohort sat an Applied Mathematics exam, continuing the trend of years previous. This is despite the fact that some 25%-35% of students achieve an A grade at Higher Level Applied Mathematics making it one of the easier subjects in which students can achieve high grades. The reason for the low uptake in Applied Mathematics is undoubtedly due to its perceived mathematical content and difficulty together with the knowledge that it is mainly appropriate to students who intend to study Engineering and Technology courses at Third Level. An additional factor is that the course is not actually offered at every school, particularly in girls' schools. Even in schools were it is available it is taught after official school hours as it is perceived to be an 8th Leaving Certificate subject.

It is apparent that in recent years Applied Mathematics has been treated with disregard by the NCCA. To highlight this point it must be stated that the current curriculum has not been significantly revised for over thirty years[16]. Applied Mathematics is a hugely important subject which nurtures the problem solving ability of students and provides context allowing students to appreciate the 'usefulness' of Mathematics and where many mathematical concepts are applied in the real world. It also provides a very useful introduction for students who intend to study Science, Engineering and Technology (SET) courses at Third Level. A completely new approach is now required for Applied Mathematics. It is crucial that at a time when minority subjects are being axed we protect and revise this subject. Engineers Ireland are aware that

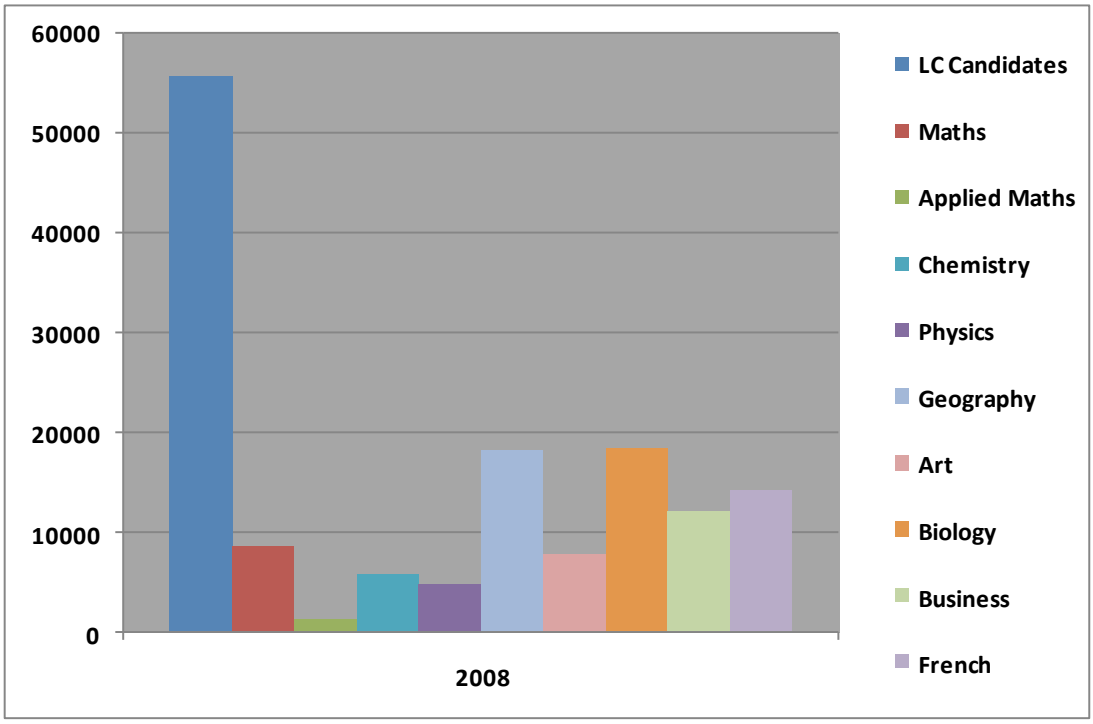
Applied Mathematics is being considered for revision as part of the Project Maths initiative/approach and fully supports the NCCA in this regard.

The uptake of Chemistry and Physics at Higher and Ordinary Level while significantly higher than that of Applied Mathematics is also relatively low, especially when compared to the numbers taking other subjects e.g. Geography and Biology. In relation to Chemistry the percentage of students examined in this field has increased marginally since 2001. The period 2001-2006 witnessed a 2.4% increase where in 2006 numbers peaked at 13.1% of the cohort. The following two years witnessed a slight decrease in the percentage of students taking this subject however this trend has since been discontinued in 2009 where a small increase on the year previous was recorded. 2009 was the first year since 2001 that Chemistry proved more popular than Physics. **In summary, Chemistry and Physics continue to be minority subjects as is the case with Applied Mathematics.**

The percentage uptake of Leaving Certificate Physics peaked at 14.8% in the years 2002 and 2003. 2004 witnessed a downturn in the numbers, a trend which has since continued. In fact a trend line shown above indicates that since 2001 the percentage of Leaving Certificate students taking the Higher Level Physics paper has consistently decreased. In 2009 just 12.1% of the cohort sat a Leaving Certificate Physics exam.

The objective of the NCCA is to increase the percentage taking Chemistry and Physics subjects at Leaving Certificate to somewhere in the region of 20% of the cohort however this target appears to be some way off[17]. Figure 11 below illustrates how the take up of Mathematics, Applied Mathematics, Chemistry and Physics at Leaving Certificate Higher Level compared to other subjects for the year 2008.

Figure 11 - Number of LC Higher Level Examinations for Numerous Subjects, 2008



On examination of this graph it is apparent that there are substantial differences between the Science, Technology, Engineering and Mathematics (STEM) subjects and

the more attractive subjects such as Geography, Biology, Business, Art and French. Anecdotal evidence suggests the latter subjects attract more numbers at Higher Level as students do not fear them while it has also been suggested that these subjects are delivered in a more vibrant fashion creating context which interests students and aids them in their understanding.

Furthermore the curricula are not as demanding in terms of time and effort. **Time and effort tend to be the most significant reasons given by students who are capable of studying Higher Level Mathematics but choose not to**. With the pressure for points across all of their subjects, students find Higher Level Mathematics requires significantly more time than other subjects meaning they can't afford to take it. This often makes the decision to drop down to Ordinary Level a "strategic" one and Mathematics is treated as a spare. Some students even voluntarily take up an additional 'interesting' subject in grind schools at weekends to compensate for dropping from Higher Level to Ordinary Level Mathematics.

Figure 12 - % Uptake of Applied Mathematics by Gender

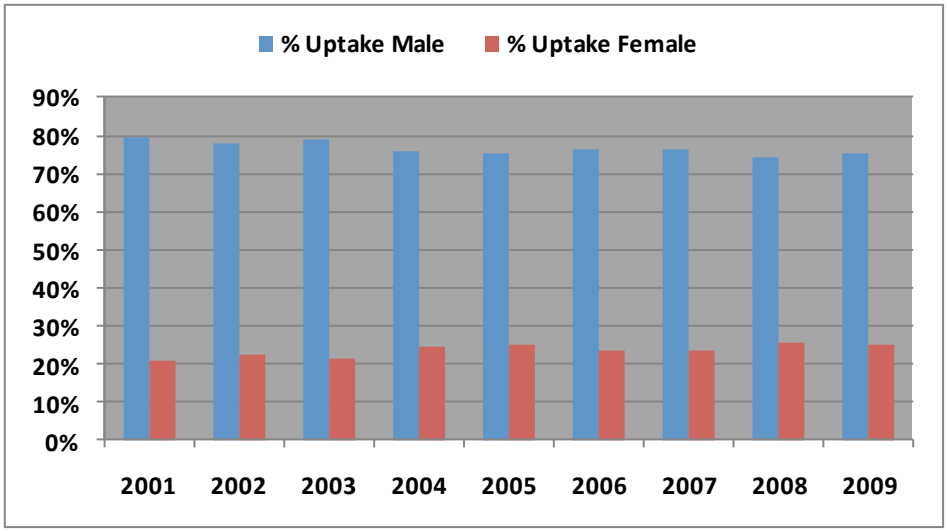


Figure 12 illustrates the gender imbalance present in Applied Mathematics. It is evident that the majority of students sitting Applied Mathematics exams are male. In 2001 only 20.6% of the Applied Mathematics population was female. This figure increased to 24.5% in 2005. However there has been little change since.

Figure 13 - % Uptake of Physics by Gender

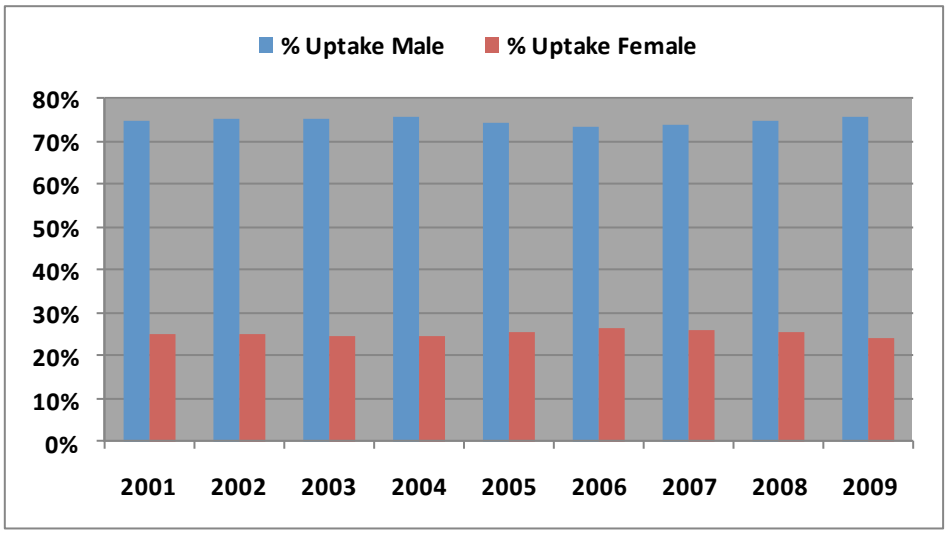


Figure 13 illustrates the gender make-up of Leaving Certificate Physics. Once again it is evident that the male population far exceeds that of the female for this subject. In 2009 75.8% of students sitting a Physics exam were male.

Figure 14 - % Uptake of Chemistry by Gender

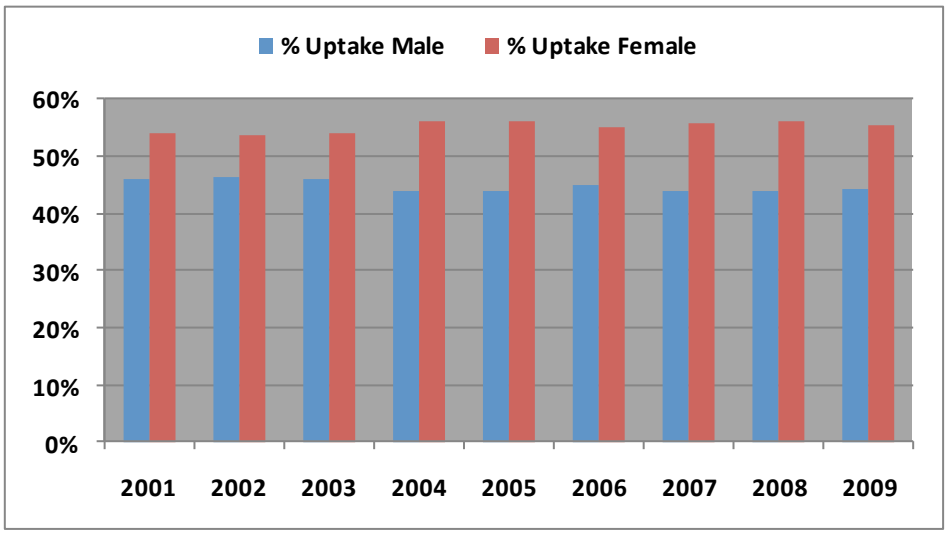


Figure 14 illustrates the gender make-up of Leaving Certificate Chemistry. This is the only Physical Science subject where the number of female participants outweighs that of the males. Evidently the balance between males and females in this subject is more desirable. Females represented 55.60% of the entire Chemistry population at Leaving Certificate Level in 2009. **It is vital that more females are encouraged to take STEM subjects at both Junior and Senior Cycle Level.**

2.5 Transition Year

The Transition Year programme has been in existence in Ireland since the 1970's. Its popularity has however only recently increased. It is an optional year, one which affords those who have completed the Junior Certificate the opportunity to develop a range of

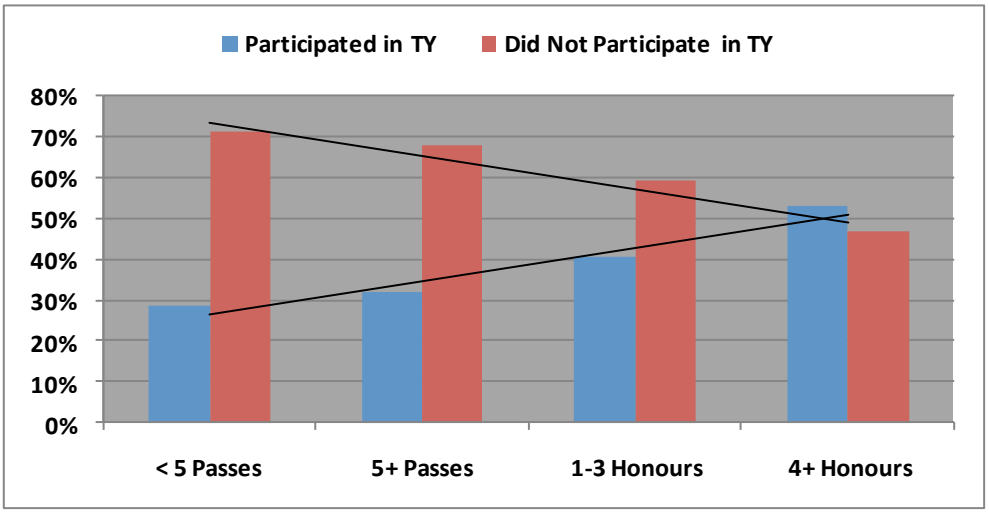
competencies not usually emphasised within the traditional academic calendar. Transition Year instead focuses on the development of personal and social skills, offers a taste of future Leaving Certificate modules, encourages self directed learning and provides an insight into the 'real world' working environment. Currently there is no standard curriculum devised for this year (nor a standardised assessment) allowing schools a considerable degree of autonomy in the design of their own programme. **Over 70% of Second Level schools offer Transition Year to students[18] yet only about 25% of all Senior Cycle students actually do it.**

Mathematics in Transition Year seeks to stimulate student interest through practical activities and investigatory problem solving. In this way students can make connections between Mathematics and the real world while it allows for a more pupil directed approach to the subject. The main aim of Transition Year is to increase confidence amongst students and increase self awareness of their potential.

Science in Transition Year is often used as an opportunity to introduce students to new areas not previously encountered for example Astronomy, Food and Agricultural Science. It also provides a basis for further study in a Science related field, such as energy, where the links between science and society can be explored. Student activity is stressed while a more investigatory approach is used than that of the Leaving Certificate course. On completion of Transition Year the student should have a broader understanding of the subject[19].

In considering the relationship between participants of the programme and Leaving Certificate results there are notable trends. In 2007 53.3% of those who achieved four or more honours had undertaken Transition Year, a trend reflected in the 2006 statistics. This fact is illustrated in Figure 15. **This graph indicates that the more successful the student at Leaving Certificate the more likely they are to have participated in the Transition Year programme.** Some argue that the reason for this is more likely related to social backgrounds (students from professional background are twice as likely to participate) rather than the impact the programme has on grades[20].

Figure 15 - 2007 LC Examination Results by Participation in Transition Year



However a recent study has (The Transition Year Programme: An Assessment: 2004) indicated that participants of the Transition Year programme outperform non-participants in Mathematics, when all else is equal[21].

The same study also concluded that being a year older as a result of participation does not enhance Leaving Certificate academic performance. Rather it suggests that pre-exposure to subjects studied at Leaving Certificate was more likely to have a positive effect. The emphasis Transition Year places on self directed learning and the consequences of participation on student maturity are also considered as contributors to enhanced levels of academic performance. There is also anecdotal evidence that suggests some schools use Transition Year as a 3rd Leaving Certificate year and begin the actual course at this point.

Students who take part in Transition Year are more likely to go onto Higher Level education. **However Transition Year also appears to sway students in the direction of Business and Humanities courses in both Senior Cycle and Third Level education. This is particularly true for males. This fact is most likely to be a reflection of the likely content of the Transition Year tradition of 'work experience' towards business activities (e.g. mini-banks etc) promoted in preference to scientific or engineering challenges**. The emphasis placed on the interpersonal rather than the practical skills may also be a contributing factor.

2.6 Qualitative Assessments

The foregoing sections of this chapter give an outline of statistical outcomes in Mathematics and Science performance at Junior and Senior Cycles over the past ten years or so. These statistics demonstrate relatively low uptakes of Higher Level Mathematics and Science subjects at Leaving Certificate with the exception of Biology. The figures also show particularly in the case of Mathematics that the low uptake of Higher Level papers is evident at Junior Certificate Level relative to other subjects. **One can therefore conclude that the significant problem with Mathematics is at Junior Cycle or Primary Level including a lack of consistent 'joined up' thinking across the transition between Primary and Second Level. There is also a serious lack of intelligence transfer regarding students. This will take a completely new approach over many years to rectify.**

The NCCA have undertaken a number of studies and reports both nationally and internationally over the period 2005 to 2007. These have identified a number of specific areas of concern in relation to Second Level Mathematics education:

- The emphasis on procedural skills and on 'rote learning' rather than 'learning through understanding'.
- Poor application of Mathematics in real world contexts.
- Low uptake of Higher Level Mathematics especially in the Leaving Certificate.
- Low grades at Ordinary Level especially at Leaving Certificate.
- Gender differences in uptake and achievement.
- Difficulties in Mathematics experienced by some students in Third Level courses.

Experience internationally shows that these difficulties with mathematical competence are not only confined to Ireland but are present worldwide to varying degrees. Arising from the identified areas of concern there is also a general consensus that Mathematic achievement

in Ireland is problematic both for 'scientific advancement' and in terms of 'Mathematics for all' i.e. for ordinary everyday life.

Ireland's current economic and social goals to become a leading 'knowledge economy' of world class quality are seriously challenged by our relative lack of 'high achievers' in Mathematics. There are ambitious goals for Irish Universities to be in the top quarter of the OECD league of International Universities but these ambitions are not likely to be realised with current mathematical standards. They are severely challenged by the current lack of human capital and infrastructure in Ireland. There are clear signs of a general deterioration in standards. The NCCA 2005 Report on International Trends in Post-Primary Mathematics Education notes that Ireland was rated 5th out of 39 countries for 'reading literacy' but 20th out of 40 for 'mathematical literacy'. It was also noted that Ireland had 'comparatively few very high achievers and very low achievers'[22].

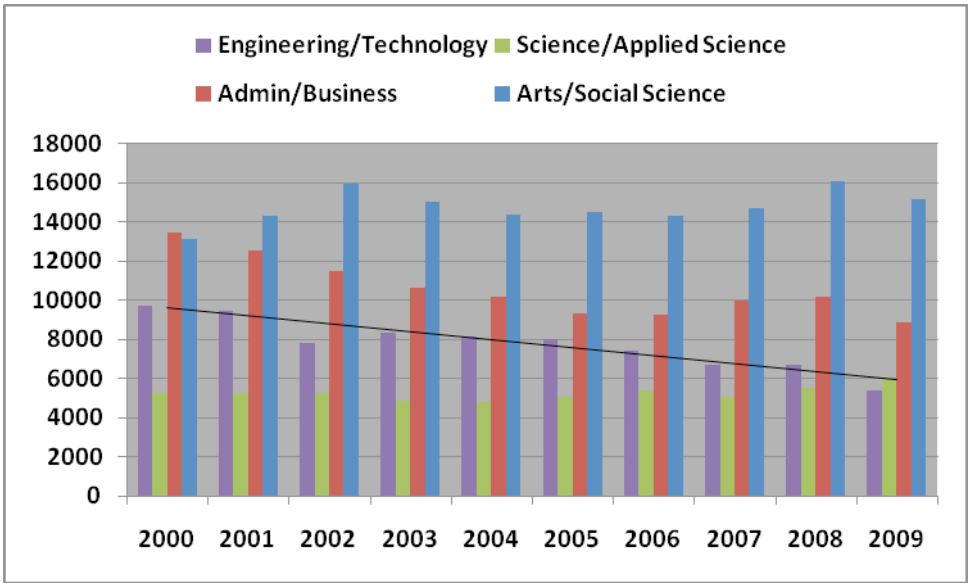
The relatively low level of high achievers raises concerns about whether Second Level Mathematics education is preparing a sufficient number of students to meet the demands of the knowledge society which will need a pool of researchers and other professionals for a range of fields including Mathematics graduates to enter the teaching profession. In this latter regard it is noted by the Expert Group in Future Skills Needs (EGFSN) that only about 20% of teachers of Second Level Mathematics study Mathematics beyond the first year of their primary degree[23]. There is no direct evidence for this claim however, it is a best estimate.

This has been part of the motivation for new legislation from the Teaching Council setting specific requirements for the content background for teachers seeking initial registration. On the other hand it needs to be pointed out that all Level 8 graduates of engineering have a degree that includes mathematics as part of their course and many of these are now seeking an alternative career due to the severe recession.

2.7 CAO Statistics

As previously stated the current aim of the Irish Government is to produce a world class knowledge economy which can compete at the highest international levels. High end engineering and science graduates are a fundamental requirement of this ideology. In order to produce these high end graduates we must attract greater numbers of high end Leaving Certificate students to SET courses. Figure 16 below illustrates the number of Level 8 first preference applications made by Leaving Certificate students to various educational disciplines in previous years.

Figure 16 - CAO First Preference Applications by Course



On examination of the numbers it is evident that the current interest in Engineering and Science falls far short of those interested in Business and Art degrees[24]. **While the number of first preferences for Level 8 Science courses has increased in recent years it is evident that the numbers selecting Engineering as a first preference is in serious decline (approximately 50% reduction between 2000 and 2009).** The current downturn in the construction industry has undoubtedly had an impact on the numbers selecting Engineering in 2009.

The low level interest in Science, Engineering and Technology courses is further emphasised by the ever declining entry requirements associated with these courses. Low level entry requirements can act as a deterrent to those who could and perhaps should undertake degrees in Engineering and Science as selecting these is considered to be wasting points. They also inevitably lead to high dropout rates as students are ill-equipped to tackle the mathematics content of the courses. It is estimated that in 2008 across the 7 Universities the dropout rate for SET courses was 20%. Figures released by the Irish Times in May 2009 indicated one particular University had a dropout rate of 39% across their Science and Engineering courses[25].

The Royal Irish Academy (RIA) in 2009 found that 60% of school leaver's who have taken Higher Level Mathematics do not take a Science or Engineering subject at Third Level[26]. These are the very people we must attract to meet our future skills needs and to help us excel as an innovative 'smart economy'. Responsibility for this figure must also lie in part with the Career Guidance Profession who are currently not doing enough to encourage students to participate in these courses and perhaps the Engineering profession itself is not doing enough also to attract students to its Third Level courses. Engineers Ireland will seek to attract more highly mathematically numerate graduates to its courses by raising its profile and incentivising both students and teachers towards engineering courses.

Chapter 3 Curricula Challenges

3.1 Introduction

This chapter discusses the current curriculum challenges which exist in Irish schools. In particular the Mathematics curriculum is examined at Primary and Second Level. The Project Maths initiative designed to increase the uptake of Higher Level Mathematics and to address many other well documented issues is also discussed in detail as are key difficulties associated with implementing this programme. Mathematical ability is particularly important due to the fact that it impinges on many other subjects in particular the Physical Sciences. This statement along with the current gap which exists between Primary and Second Level curricula is also examined in this section of the report together with various other issues that appear to impinge on subject outcomes and assessments.

3.2 Early Childhood Learning

Early childhood in Ireland is considered to be from birth to eight years. Research has shown that early childhood is an important time for developing the child's ability to persevere, take risks and solve problems; to develop confidence and independence; to nurture curiosity and to develop an identity as a learner[27]. Early childhood is a time of tremendous opportunity for learning, a time when the foundations for all later learning are laid. During these early years a child may spend time in various settings where adults can use a variety of approaches to assist them to learn and develop. These settings may include the home, child minding settings or day care settings. Until 2009 there had been no national curriculum for children outside of the Primary school sector.

Recently however the NCCA has taken steps to rectify the situation. Aistear, The Early Childhood Curriculum Framework was launched in 2009 aimed at providing parents, child minders and practitioners responsible for the learning and development of children with a useful framework. This framework has been introduced to ensure that early childhood provision is structured, developmental and of high quality enabling children to become confident and competent learners. Aistear offers guidelines to adults on how to provide a range of experiences and learning opportunities to enhance childhood development while supporting the current Primary Level curriculum.

The framework is divided into two parts, the underlying themes of the framework and a series of practical guidelines. These themes include Well Being, Identity and Belonging, Communicating and Exploring and Thinking and their messages are conveyed to children through play, interactions, and partnerships with parents and assessment. With regard to Mathematics and Science education, the latter two themes are most relevant.

Through the Communication theme, Aistear aims to enable children to:

- Use language to interpret experiences, to solve problems, and to clarify thinking, ideas and feelings.
- Use books and Information and Communications Technology (ICT) for fun, to gain information and broaden their understanding of the world.

- Build awareness of the variety of symbols (pictures, print and numbers) used to communicate and understand that these can be read by others.
- Develop counting skills and a growing understanding of the meaning and use of numbers and mathematical language in an enjoyable and meaningful way[28].

Through the Exploring and Thinking theme, Aistear aims to enable children to:

- Come to understand concepts such as matching, comparing, ordering, sorting, size, weight, height, length, capacity, and money in an enjoyable and meaningful way.
- Demonstrate their ability to reason, negotiate and think logically.
- Use their creativity and imagination to think of new ways to solve problems[29].

Another early childhood teaching method used throughout Ireland is the Montessori Method. Through Montessori a child's natural passion for learning is encouraged through the provision of purposeful activities with the guidance of a trained adult. Montessori is most commonly used in Ireland to teach Primary class (3-6 year old children). As part of Primary class students are introduced to Mathematics. Specifically, children are introduced to the numbers 1-10, the decimal system and various operations in Mathematics. At this time they are also given an understanding of basic mathematical concepts through activities while the use of concrete materials is used to encourage abstract thinking[30].

A study, Evaluating Montessori Education, conducted in Milwaukee on students who had completed Primary class Montessori and those who had attended schools using traditional methods has shown that Montessori education leads to children with better social and academic skills. In relation to Mathematics in particular, the study found 5 year old Montessori students to be significantly better prepared for elementary school Mathematics than non Montessori students[31].

A Montessori classroom typically has a teacher/pupil ratio of 1:15 and is open five days a week for a minimum of three hours a day. In order to be accredited by the Irish Montessori Education Board the teacher must hold a suitable award[32].

3.3 Primary Education

At Primary Level the majority of young minds are exposed to the world of Mathematics and Science for the very first time. It is a time where we must provide children with the initial knowledge and skills they require to develop an understanding of the physical world. More importantly however it is a time where we must seek to stimulate enjoyment and enthusiasm whilst harnessing natural childhood curiosity in these most important of subjects.

Both Mathematics and Science are taught from Junior Infant's right up to 6th class. These modules form part of the current Primary Level curriculum and were first implemented in 2001 and 2004 respectively[33].

Mathematics

According to the NCCA, Mathematics at Primary Level gives the child a language and a system through which he/she may analyse, describe and explain a wide range of experiences, make predictions, and solve problems[34]. It strives to foster creative and

aesthetic development while enhancing the growth of reasoning through the use of investigative techniques in a mathematical context.

The Primary Mathematics curriculum consists of five strands; Number, Algebra, Shape and Space, Measures & Data. A recent report into Primary Level education conducted by the NCCA highlighted particular problems related to the current curriculum:

- Teacher observation was found to be the most frequently used assessment method. Three challenges were identified for assessment namely time, appropriateness and catering for the range of mathematical ability.
- There was limited use of pair or group work in class.
- Only 58% of teachers used ICT to support the Mathematics curriculum.
- The greatest challenge was in catering for the range of student ability with time as the main constraint. Implementing specific curriculum content areas also posed a challenge as did accessing resources.
- Pupils are likely to receive three times more assistance with their English as they do with Mathematics from learning support teachers[35].

A separate report conducted by the Education Research Centre (Counting on Success) on Primary Level Mathematics found that:

- Between 1999 and 2004, there was a significant decrease in the amount of time allocated each week to teaching Mathematics in 4th class.
- Just 15% of inspectors expressed satisfaction with the amount of Mathematics homework assigned to pupils[36].
- 70% of inspectors described teacher's knowledge of methods of teaching Mathematics as "somewhat limited".
- Textbooks overused and more activities are required to develop mathematical language and to apply concepts to real life.
- Just 10% of teachers had a 'very comprehensive' knowledge of mathematical concepts and processes.
- Need identified to accord greater attention to problem solving strategies.
- Lack of time for teachers to complete Mathematics curriculum.
- Learning support for Mathematics inadequate especially when compared to that of English. Teachers felt that provision of learning support for English was prioritised and provision for Mathematics marginalised.
- Strands Algebra and Data and processes of reasoning, integrating/connecting, and applying/problem solving in need of attention in pre-service teacher education and professional development courses[37].

Improving the everyday context of Mathematics is critical at all levels of the educational system. This must be done so that students not only relate to the material but so that they can visualise the various concepts behind lessons. This will enable better understanding of subject content and where specific concepts can be applied to everyday life. The images below demonstrate examples of how the everyday context of Primary Level Mathematics can be improved through activity based learning. The photographs of Primary Level shown in this Chapter are with the kind permission of the NCCA.

Figure 17 - Improving the Everyday Context of Mathematical Education at Primary Level


One major finding in relation to Primary Level education is that 28% of new Primary school teachers felt themselves to be 'poorly prepared' to teach Mathematics. This suggests that not enough resources are being made available to teachers to ensure that they themselves feel adequately prepared and confident in their own ability[38].

Science

The Science curriculum at Primary Level aims to develop basic scientific ideas and understanding in children. It aims to develop both conceptual and procedural understanding and knowledge through the skills of working scientifically and designing and making. The curriculum is divided into four strands; Living Things, Energy/Forces, Materials and Environmental Awareness/Care.

A report conducted by the NCCA which questioned teachers on the Science curriculum found that:

- 12% of teachers stated that they provided opportunities for their pupils to investigate Light and Sound on a monthly basis, 9% for Heat and Forces and just 7% for Magnetism and Electricity.
- The main challenges associated with the teaching of the individual strands were time, space, resources and class size.
- Investigating & experimenting, analysing, estimating and measuring were the skills afforded least amount of attention during class.
- Just 12% of teachers frequently provided students opportunity to design and make[39].

One other key finding in relation to the teaching of Science in Primary schools was that only a minority of Primary teachers have taken a Physical Science subject (mostly Biology) to upper Second Level[40]. This is a major concern as the majority of

teachers do not possess the necessary knowledge and skills to communicate lessons confidently and effectively to their audience.

3.4 Second Level Education

Mathematics

Currently the NCCA is reviewing the area of Mathematics at Second Level. This review is being conducted in an effort to address a number of key issues of concern regarding Mathematics. Industry leaders and Third Level colleges in particular are concerned with the low level mathematical ability of students emerging from Second Level education in Ireland. The main areas of concern relate to the uptake of Higher Level Mathematics, the Leaving Certificate examination results and the general standard of classroom teaching and learning. The mathematical ability of our Engineering students is hugely important for both their career development and the future Irish 'smart economy'. The NCCA are acutely aware of the existing problems in Mathematics and the 2000 Junior Cycle Curriculum did emphasise 'teaching for understanding' and the use of 'active teaching methods' and stress on proper communication. However it is now widely believed that a more radical approach is required. This belief has in turn led to the 'evolution of Project Maths' described in the next section of this report.

There have been a number of reports published recently on Second Level Mathematics. Some of the main points outlined in these are:

- 16% uptake of Higher Level Mathematics at Leaving Certificate in 2009 down from 17% in 2008. This does not match the expected uptake of 20-25%, the NCCA target.
- In 2008 the failure rate at Ordinary Level was 12% of the cohort. These students could not apply to Engineering or Science courses as they did not meet the course requirements.
- Anecdotal evidence suggests students taking 7 Leaving Certificate subjects treat Mathematics as a spare and opt for Ordinary Level.
- Nearly two thirds of Junior Certificate Higher Level Mathematics students drop to Ordinary Level for Leaving Cert.
- It is estimated that just 20% of Second Level teachers studied Mathematics as a major subject beyond the first year of their Primary degree[41].
- Students are being prepared to pass exams in Mathematics but are not given an understanding of Mathematics or of how to apply mathematical concepts. As a result, many of these students can end up struggling to keep abreast of the workload at Third Level or apply their knowledge within the workplace environment[42].
- Concerns have been expressed that the Mathematics and Science are not given sufficient priority within the school curriculum[43].

In a survey conducted for the NCCA, Review of Mathematics in Post-Primary Education, 90% of teachers considered better in-service for teachers as well as improved Mathematics textbooks and other resources would likely be 'very effective' or 'effective' in improving student performance in examinations. The allocation of more class time to Mathematics was

seen as being another effective measure by most respondents who highlighted a reduction of class time for Mathematics as a result of an expanded Junior Certificate Curriculum[44]. A recent Irish Business and Employers Confederation (IBEC) education message 2008 also alluded to the fact that the time allocated to Mathematics at Primary Level has been significantly reduced over the last decade. Further evidence presented by the OECD claimed that out of 22 countries surveyed only two spent less time teaching Mathematics Science and Technology to 9-11 year old students than Ireland[45].

In relation to the evidence suggesting students are being prepared to pass examinations rather than being given a true understanding of mathematical concepts it must be noted that this is in part due to pressure from both parents and students who wish only to achieve maximum CAO points. This has led to calls from some industry quarters for the reintroduction of 'bonus points' for Higher Level Mathematics at Leaving Certificate based on the need to incentivise students to spend the additional time which the subject obviously requires. There is however no clear educational consensus on this issue.

The use of calculators is an area of divergent views among Primary and Second Level teachers and principals. While calculators have taken the tedium out of mundane calculations they are unfortunately part of the 'rote learning' of current educational practice in Ireland. They have also played a role in diminishing standards of mathematical understanding and literacy leading to mediocrity in Mathematics at higher levels of education. Engineers Ireland recognises that there is evidence suggesting that the use of calculators leads to improved performance. However we would suggest that while calculators allow students to produce correct answers, therefore improving performance in assessment as students are likely to be competent in using simple calculator functions, they are over-reliant on them at an early age hindering their progression and numerical ability. In fact teachers themselves while acknowledging that they offer some educational benefits, i.e. improvements in accuracy, have expressed concern of a general decline in aspects of numeracy (mental arithmetic, estimation, concepts, tables, and computational skills)[46]. Indeed there is anecdotal evidence from teachers of First Years in Second Level schools being unable to multiply say '7x8' without a calculator! Engineers Ireland are seriously concerned at these reports.

Project Maths

Three years ago the NCCA began to review the current Mathematics syllabus and evaluate the latest mathematical international trends in terms of best practice, technology, content and teaching methodologies. This was done in an effort to improve the standard of mathematical education in Ireland, the low uptake of Mathematics at Higher Level and other well documented problems. Project Maths, the most radical reform of Mathematics education in Ireland for over forty years arose in response to this review.

This new initiative aims to address the problems associated with the current 'tired' curriculum outlined in this report through the introduction of innovative teaching and learning practices and the promotion of learning for understanding. In particular it seeks to develop problem solving skills and strategies which can be applied to different contexts/scenarios and to develop learner confidence and competence. As part of Project Maths the NCCA also intend to provide support for students with educational needs as well as students who are exceptionally able at Mathematics.

Project Maths also aims to significantly dilute the use of 'rote learning' of Mathematics as a series of formulae to be learnt and procedures to be followed as such methodologies do not foster real understanding. Indeed this methodology of learning Mathematics has been likened to learning English through the study of grammar but with no exposure to literature or poetry.

Currently Mathematics is examined at two cycles in Second Level; Junior Certificate and Leaving Certificate. This will continue under the new Project Maths initiative. At Junior Certificate there are to be two syllabi levels Higher and Ordinary; Ordinary being a subset of the Higher Level. This represents a change from the current three levels which are offered at Junior Certificate. There is also a Foundation Level examination paper which will be based on the Ordinary Level syllabus rather than a 'Foundation Level syllabus' as is the case today. Leaving Certificate contains three syllabus Levels; Higher, Ordinary and Foundation, each a subset of the other. The target of Project Maths is to have at least 60% of the cohort at Higher Level for Junior Certificate and 30% at Leaving Certificate[47].

Project Maths places the emphasis on understanding and interpretation of mathematical problems rather than rote learning, although the latter practice is not completely ruled out. Proactive methodologies are employed in the classroom with students actively involved in their learning while an investigative approach is adopted. One of the main messages of Project Maths is that Mathematics be learned in contexts which establish connections between Mathematics and other subjects as well as real world applications. It seeks to promote teamwork in the classroom with students working co-operatively in groups and provided with opportunities to develop five key skills; communication, information processing, working with others, being personally effective, critical and creative thinking.

With the introduction of Project Maths the NCCA intend to change Ireland's attitude to Mathematics at Second Level. Another positive message emanating from the NCCA is their willingness to respond to feedback from learned bodies and academics as they seek to maintain and improve standards. They also recognise there are difficulties in the scaling of the programme as it is to be spread to all schools throughout the country and are determined to implement this programme successfully.

The proposed syllabus consists of five strands:

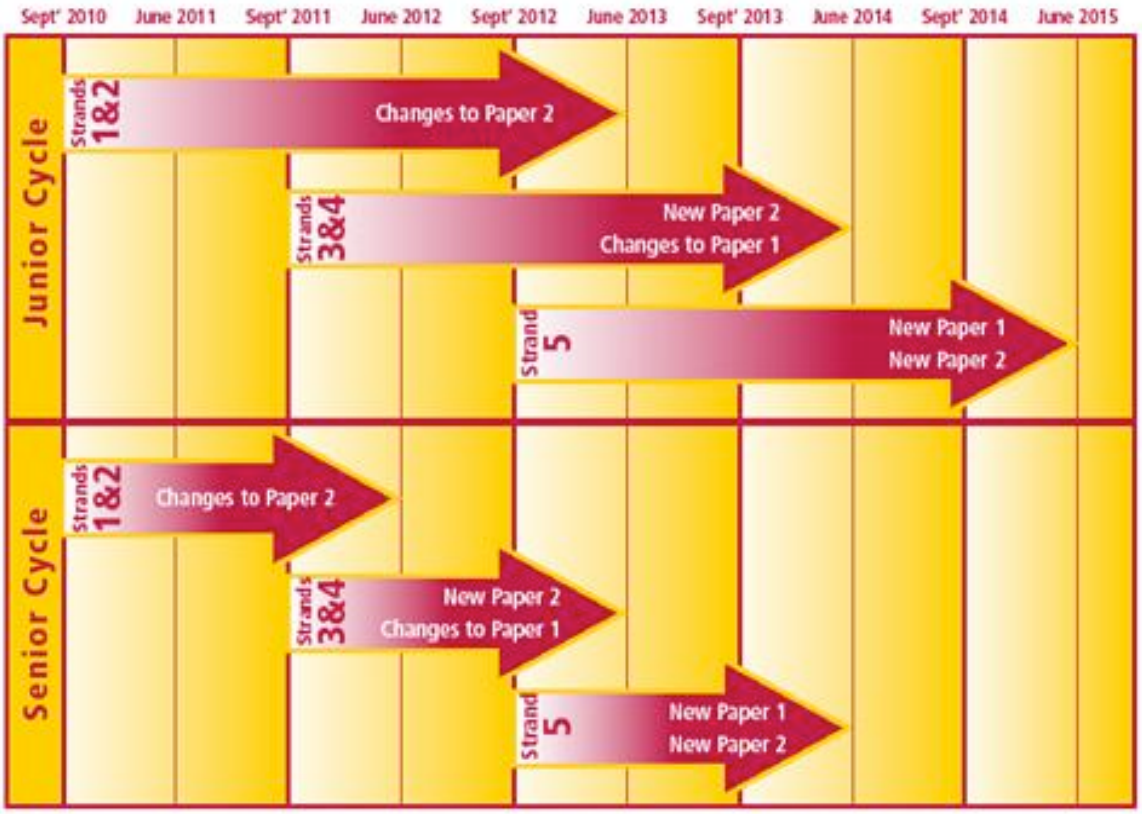
Strand	Strand Content
1	Statistics Probability
2	Geometry Trigonometry
3	Number
4	Algebra
5	Functions

Currently 24 schools are participating in the Project Maths programme. The geographical locations of the schools in question are shown in Appendix B on the map and listing. The timeline for the rollout is shown in Figure 18.

As can be seen only strands 1 and 2 – statistics, probability, geometry and trigonometry – will apply in teaching and assessment in Year 1 (Sept 2010 to Sept 2011), then strands 3

and 4 the following year and strand 5 (Functions) starting to be taught in September 2012. It will be 2015 before the full extent of the new syllabus is felt and many years afterwards, certainly up to 2020 before the new approach can be assessed for success or otherwise. However, though a long term project, it does appear to be the correct approach to the current problems being experienced provided it is resourced adequately.

Figure 18 - Project Maths Timeline[48]



It should be stated in fairness to the traditional form of teaching that there were many great teachers who consciously or unconsciously used some or all of the admirable merits of the Project Maths approach and who achieved great student successes. We would not wish to attribute poor mathematical competence to the teaching profession in Ireland as that would be unfair. Some institutionalised methods of teaching did exist in the past though for the most part, these methods are now historical.

Engineers Ireland's primary concern with regards to Project Maths is that it does not appear to be very well resourced. It must be ensured that adequate teacher training, books and other materials such as sample papers are widely accessible. This is critical for successful implementation. Incredibly only one sample paper has been made available to the initial schools involved with Project Maths thus far meaning teachers and students have very limited guidance as to the presentation of exam questions. Concerns have also been raised by commentators who suggest that there are aspects of Project Maths which appear ill-conceived and poorly thought out. The aim to bring 17% of students currently taking the Higher Level paper to 30% in the short term appears inconceivable and has led to concerns that Project Maths is diluting or 'dumbing down' Mathematics. These concerns must be addressed as any errors incurred now could have a devastating impact on the mathematical ability of future Irish students.

Science

Science at Second Level deals with the discovery and knowledge of our world. At Junior Cycle Science is taught as one single module comprising Physics, Chemistry and Biology. Science at this level involves the study and understanding of a body of knowledge and the development of scientific skills through practical work. Junior Certificate Science aims to reinforce and further develop in the young person the knowledge, understanding, skills and competencies acquired at Primary Level.

At Senior Cycle the three Science topics are broken up into individual subjects. Physics at Senior Cycle Level aims to give students an understanding of the fundamental principles of Physics and their application to everyday life and technology. Chemistry aims to encourage an understanding of the scientific, social, economic, environmental and technological aspects of Chemistry and an understanding of the historical development of Chemistry. Various reports have been conducted in relation to the standard of Science at Second Level. One substantial report completed by the Taskforce on the Physical Sciences outlined the following findings:

- Girls are less likely to study Science than boys, a difference which is attributable to school provision rather than student choice. For example many girls and their schools choose to do Home Economics instead.
- 83% of 1^{rst} year students indicated that they would either "definitely" or "probably" continue to study Science. By the time students have completed Junior Certificate Science interest had declined to the extent that only 39% of the cohort indicated that they would continue to study Science.
- A large proportion of students (73%) indicated that Junior Certificate Science had some impact on their decision not to study Physics or Chemistry to Leaving Certificate Level.
- One major contributor to the low uptake of Physical Science subjects at Leaving Certificate Level is the comparative difficulty of achieving high grades in these subjects. Leaving Certificate candidates are less likely to perform as well in Physics and Chemistry than in other subjects.
- A survey carried out by the National Association of Principals and Deputy Principals (NAPD) suggests that within the Science teaching cohort in Second Level schools, just 27% of teachers have Physics to degree level while only 29% have Chemistry to degree level[49].

Engineers Ireland wish to note that the DES has taken steps to address the issues which were outlined by the Taskforce on the Physical Sciences, most notably in relation to the increase in the amount of practical work undertaken by students. It is however important that any changes that have been made be evaluated in the near future to ensure that the serious issues raised in that report have been addressed.

Listed below are some other key points that have been raised in a recent Oireachtas report (Science and Mathematics Education in Ireland: Provision, Participation and Achievement):

- Ireland unique amongst 21 European nations in that Science is not compulsory at lower Second Level.

- Students in Irish schools receive a lower proportion of teaching time in Science compared to the OECD average and EU, 8% of instruction time compared to average of 12%.

- Ireland has proportionally fewer students failing to reach lower competency scales than averages in other OECD countries, however room for improvement among Higher Level students.

- Quality and quantity of laboratory equipment expected over next decade very poor.

- Up to 25% of schools in some regions of the country forced to drop Leaving Certificate Science subjects due to teacher cuts[50].

One of the major concerns for Engineers Ireland is the lack of adequate laboratory facilities available for the Physical Sciences at Second Level. Even when these exist the maintenance and supervision required to maintain adequate Health and Safety standards is often sub-standard.

Notwithstanding the foregoing the Young Scientist Exhibition firstly sponsored by Aer Lingus and now sponsored by BT has greatly increased student and public appreciation for the world of science and also so has curriculum projects initiated by Intel Ireland and other process industries. The SciFest initiative which collaborated with many of the Institutes of Technology is also worthy of note.

3.5 Mathematical Education

The foregoing sections of this chapter highlight numerous issues impacting negatively on the education of Mathematics and Science at all levels. One key issue of concern for Engineers Ireland is in relation to the need to resource and support teachers to equip them to undertake their tasks adequately. Presently it appears that teachers cannot best serve the interests and needs of pupils if they do not possess the appropriate knowledge and educational skills to communicate effectively. This is a very prominent issue due to the fact that many of the teachers will be unfamiliar with the content and some of the methodologies proposed by Project Maths. The anecdotal evidence from interfacing with a number of Second Level teachers is that the new Project Maths approach is far more challenging for teachers than it is for students. A very significant retraining and reorientation is now required for teachers taking up the new curricula.

In order to rectify this situation and to further improve the teaching of these subjects more relevant mathematical and science education is required. Many Third Level Institutions including NUIG have recently taken steps to improve standards through the introduction of a new programme. On completion of this programme participants are to be awarded a BA in Mathematics and Education. The ethos of this programme is to support the development of Mathematics and Applied Mathematics teachers who are both knowledgeable and passionate about their subject. It is also hoped that through the programme future graduates may develop a lifelong commitment to the teaching of Mathematics and involve themselves in the promotion and advancement of education in Ireland. Similar courses are also available in NUI Maynooth in terms of both BSc and MSc courses in Science Education.

These programmes seek to enrich the learning potential of students, thus enhanced learning; educational innovation and creativity; and innovation in Mathematics and Applied Mathematics education underpin the programme.

For the purpose of this report NUIG has described the three major differences between the NUIG programme and the more predominant sequential approach to teacher education in Ireland through a primary degree followed by a Postgraduate Diploma in Education (PGDE).

1. The subject specialisation - in other teacher education programmes, the student teachers study two (possibly unrelated) subjects whereas in the BA, they specialise in Mathematics and Applied Mathematics. In addition, the specialisation of students in the NUIG BA is to the high level of a full honours degree in these subjects. Furthermore, existing opportunities to specifically study teaching methodologies for Applied Mathematics are otherwise limited as Applied Mathematics is typically not offered as a teaching methodology in most teacher education programmes.

2. The focus on subject-specific teaching methodologies - In some PDGE programmes the intensive nature of the programme only allows for 10-20 hours in total for the study of teaching and assessment strategies specifically focused on Mathematics. Students in this programme have a series of modules over the four years that ensure an extensive study of pedagogical techniques that are most appropriate for the Mathematics and Applied Mathematics classroom.

3. The concurrent structure allows for integration – Research conducted with students in the PGDE Mathematics methodology suggests that student teachers have a great deal of difficulty seeing the value of studying Mathematics to a high level for Second Level teaching. It is a challenge to draw these connections for the students when they are looking back on their studies, but in a programme where their education coursework is concurrent with their studies of Mathematics and Applied Mathematics opportunities can be built in for them to think more critically about their learning in real time and recognise the ways in which their development as mathematicians and teachers go hand-in-hand.

While this programme may address the standard of newly qualified teachers there still exists a problem with some teachers in education today. These teachers may benefit from engaging in an accredited Continuous Professional Development (CPD) programme or the availability of more in-service days in an effort to embrace the philosophy of lifelong learning. Initiatives such as these may go a long way to addressing the recognised need for high quality specialist Mathematics teachers in the Irish educational system. However, much rededication of teacher resources will require some innovative incentives to retrain and entice teachers to go back to a degree type period of intensive study. A noteworthy issue is the general admission practice of choosing candidates for a PGDE programme through application of a point system based on primary degree results and teaching hours experience with a notable exception of Trinity College Dublin (TCD) where an interview is the key admission factor together with academic record.

University of Limerick (UL) also offers a similar concurrent programme to NUIG which allows students to develop in content and methodology over a series of four years. This offers many of the same benefits however students in this programme have the option for specialisation in Mathematics along with another subject. Therefore, over the four years they split their specialisation between Mathematics and another subject.

The National Centre for Excellence in Mathematics and Science Teaching and Learning (NCE-MSTL) in University of Limerick is worthy of credit here in their great efforts to offer CPD both in support of, and independent of Project Maths. They sponsor a series of conferences and workshops throughout the year, offer content-based workshops for teachers in the summer and have an extensive collection of resources available to Mathematics teachers particularly for ICT through their website www.ul.ie/cemtl and for Science teachers as well through their main site www.nce-mstl.ie. The Second Level support service (www.slss.ie) working with the DES through the excellent Educational Centres operating on a regional basis throughout the country should also be recognised for their service.

Similar degrees and courses to NUIG and UL are also offered on the east coast by National University of Ireland Maynooth (NUIM) (MSc in Mathematics and Education together with the University of Cambridge). This programme is aimed at teachers who are currently teaching Mathematics but who do not have a degree in the subject. The Mathematics department at NUIM teach the Mathematics component of the course while the Education component is taught by staff of the Faculty of Education at the University of Cambridge. As mentioned earlier, NUIM also run a BSc in Science Education. Within this programme students take Mathematics, Physics, Chemistry and Biology in their 1st Year and then keep two of these subjects as well as Education to degree level. NUIM also warrant credit here for their Maths Support Centre which is opened one evening per week to Second Level students and for their development of online tools for Second Level pupils in conjunction with Meath County Council which has been awarded for two Government E-Awards this year.

Dublin City University (DCU) also run a concurrent teacher education programme in Science and Mathematics (BSc in Science and Mathematics Education). Students in this programme can choose two subjects from Maths, Physics and Chemistry. On graduation successful participants are qualified to teach their subjects to Higher Leaving Certificate Level. This degree includes many of the elements of the NUIG degree. Specifically the Mathematics course involves; the study of Mathematics pedagogy, pure and Applied Mathematics, integration of ICT in the classroom, integration with Project Maths, and a significant education project on curriculum development. The project often links with Transition Year activities and/or emphasises the relationship of Mathematics with other school subjects and the real world.

In another positive development DCU is currently working with colleagues in engineering to developing a graduate Mathematics programme for engineers. This will provide graduates with an add-on Mathematics course so that they meet the requirements of the Teaching Council. DCU's School of Mathematical Sciences and DCU's Mathematics Learning Centre (http://www.dcu.ie/maths/mlc/index.shtml) have also begun a programme under which they provide learning support in Mathematics for local Second Level school students at both Junior and Senior Cycle. This is an outstanding example of how academic bodies can support students studying Higher Level Mathematics.

Two further DCU initiatives include the introduction of a PhD in the area of Science and Mathematics. This is aimed at recent graduates and mid-career teachers who wish to enhance their teaching and educational development skills and consequently act as experts/champions for educational innovation in Mathematics in the classroom and school. The second initiative is an EU Framework 7 proposal on Mathematics education. This is led

by the University of Florence and includes 15 partners across the community. DCU/SPCD (St. Patricks College Drumcondra) is leading the teacher education strand of the project. It aims to educate teachers in the development of Mathematics exhibitions and outreach activities and to facilitate them in bringing these ideas into their classroom practice.

Engineers Ireland while welcoming the Teaching Council's decision to make a degree in mathematical and science education a requirement for new entrants would like to see similar requirements extended to existing teachers in the form of accredited CPD programmes so as to ensure all teachers meet expected standards. This is a complex problem as once a teacher is recognised by the Teaching Council their principal may ask them to teach any subjects. Teachers must only be responsible for classes which fall under the content of their degree. A significant investment by Department of Education and Science is required in this area to up-skill existing teachers of mathematics especially.

3.6 ICT Support as an Essential Tool to Visualise Mathematical Expressions

One of the key learning outcomes of these Third Level programmes is that students gain an understanding of how to engage pupils through the use of innovative technologies and Information and Communications Technology (ICT). The programmes contain a very strong emphasis on the use of mathematical and educational technologies. ICT projects which utilise hands-on and technology-enhanced learning, e.g. animation, to augment the teaching of Mathematics concepts to pupils form part of the curriculum.

ICT when used in appropriate contexts in education adds value in teaching and learning. It adds a dimension to learning that was not previously available. ICT is seen as a significant motivational factor in student learning and can support student's engagement[51]. It offers a colourful and exciting insight into Mathematics allowing students to visualise concepts and to gain a clear understanding of their relevance. Research has shown a positive correlation between the use of ICT and academic performance. The reported benefits of ICT include; gains in student achievement, increased student motivation, improvements in students higher order thinking and problem solving abilities, and the development of student's abilities to work collaboratively[52]. There are an increasing number of ICT based services available e.g. www.reachateacher.ie based in Mullingar, Co Westmeath.

Figure 19 - Use of ICT at Primary Level

However it must be stated that ICT is only really beneficial under certain conditions i.e. when used in appropriate contexts, when ICT resources are good and when at the hands of teachers with good ICT 'know-how'[53]. The teachers own confidence and competence in using ICT is therefore crucial to successful application. The new Project Maths approach will also require ICT up-skilling for some teachers not sufficiently literate in this area.

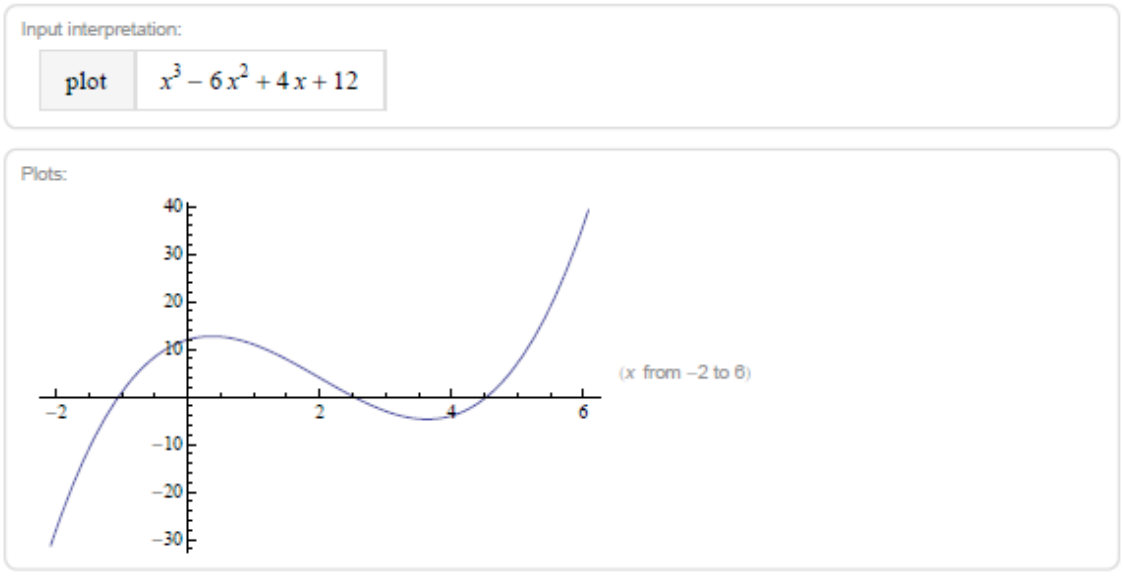
ICT is considered so important to high quality mathematical education that a number of countries have made it a mandatory part of the syllabus (Denmark, New Zealand, Luxemburg) while the US National Council of Teachers consider it a 'must have'.[54]

The use of ICT technology in Mathematics and Science education:

- Empowers teachers and students to deal with multiple representations.
- Enhances the ability to visualise.
- Increases the opportunities for development of conceptual understanding.
- Enhances individualised learning.

The illustration below shows how ICT can be used to stunning effect and aid students in visualising mathematical concepts. This particular image taken from www.wolframalpha.com shows how a teacher can generate a plot of a certain function in seconds. We must take advantage of such user friendly yet powerful tools which enable students to visualise Mathematics thus enhancing classroom learning.

Figure 20 - ICT Used to Plot a Function



3.7 Mathematics in Relation to Other Subjects

While Mathematics is an intellectual pursuit in its own right it also plays a vital role in a number of other subjects such as Business, Technology and most notably the Physical Sciences. A report conducted on this subject matter emphasised the point that teachers must be aware of the importance of Mathematics due to the unquestionable links it has with

other subjects[55]. The importance of integrating the teaching and learning of mathematical skills (the old problem of many non-Maths teachers actually hating Mathematics) in other subjects like English, Languages, Art and Music cannot be underestimated.

As a nation we have to dispel the notion that 'we don't do Math's'! Third Level Institutions have expressed concern over the mathematical ability of 1rst year student's in courses which are not fundamentally mathematics based but require certain levels of proficiency. The Primary curriculum review conducted by the NCCA indicated that teachers are finding it difficult to cross reference work between Mathematics and related subjects. It would be highly likely that this is a problem which extends to Second Level but more creative thinking on teachers would go a long way to solve the problem. Increasingly schools need to see Mathematics as an integral part of a holistic education including for example English, Languages, and Music.

3.8 Bridging the Gap between Primary & Second Level

Approximately 50,000 students make the jump from Primary to Second Level annually. This should be a time were these students make a smooth transition so that they may settle into a new environment and continue in their educational development. Research however suggests there is a definite level of discontinuity at this point. A lack of information shared between the Primary and Second Level schools is the main reason for this. The new Project Maths programme is attempting to address this serious issue.

Few Second Level schools actually receive information on all students moving up from Primary school. Currently there is no national policy on the transfer of information between Primary and Second Level schools leading to a lack of information on student's academic behaviour and specific needs. Rather many Second Level schools assess students through tests designed to identify student weaknesses and strengths.

In relation to the curriculum there is evidence to suggest that there is a mismatch between the schools when it comes to Mathematics. This can also be said for 'pedagogy' (the 'art of teaching') as the colourful images and manipulatives that are often present in Primary school tend to disappear completely in the Second Level classroom and learning becomes far more abstract. This naturally results in the student taking longer to settle in. Fortunately this is changing as modern teaching methodologies and step improvements in ICT usage become more common practice.

More than half of Second Level school teachers claim to be unfamiliar with the Primary curriculum a fact which is backed up by a third of students who claim first year essentially repeats that which they have already learned. This is a distinct waste of national resources at a time of economic distress and is due to a lack of 'joined up' thinking about education policy in Ireland[56]. Indeed we have found little or no evidence of Primary and Second Level teachers ever meeting to discuss mutual and especially continuity issues.

This is true for Mathematics but also true for Science. In fact it has been reported that 58% of teachers admit to being unfamiliar with the Science curriculum in 5th and 6th class while 69% are unfamiliar with the process skills they have learned. It has also been noted that due to the emphasis placed on written work at Second Level student expectations are not met leading to a decline in interest[57].

One other area of concern is the use of “streaming” of students which is still common in some schools. This essentially means students are labelled as “clever” or “dumb” on entry and the school can often misjudge student ability hindering their progress. It must be noted however that this method is far less likely to be used now than during the 1990s.

It is essential that there is a flow of information between the feeder school and the recipient school with regards student achievement, learning strengths and the material which has been previously covered.

It is our understanding that the NCCA recognises that there is a need for Second Level education to build on the content, learning and teaching approaches used at Primary Level Mathematics. It aims to do so with Project Maths. Project Maths comprises a Common Introductory Course at Junior Cycle Level which all students must study. This will revisit the Mathematics strands taught at 5th and 6th class so as to ensure that the Mathematics being taught and learned is appropriate to the levels of ability of the students so that they can achieve their potential in the subjects. A common glossary of mathematical terminology to be used in upper Primary and Junior Cycle Level is also to be introduced in order to build a bridge between the two levels[58].

Shown below is Figure 21 - a graphic illustrating the level of transformation that is envisaged in the attributes attaching to the current approach to Mathematics teaching and the attributes to which the new Project Maths approach aspires. Only time will tell the measure of success in this regard. Also shown in Figure 22 is a graphic of a ‘tree of learning’ which seeks to correlate how the attributes at Primary Level of Numbers, Measures, Shape & Space, Data & Algebra is picked up by the new strands in Project Maths. To be very fair to the content of Project Maths from the engineering education viewpoint, the new 'Acquired Skills' formed from the various strands are also identical to the Engineers Ireland requirements for graduate engineers in training leading to Chartered Engineer status after a suitable period of professional development.

Figure 21 - Transformation of Project Maths Approach to Learning

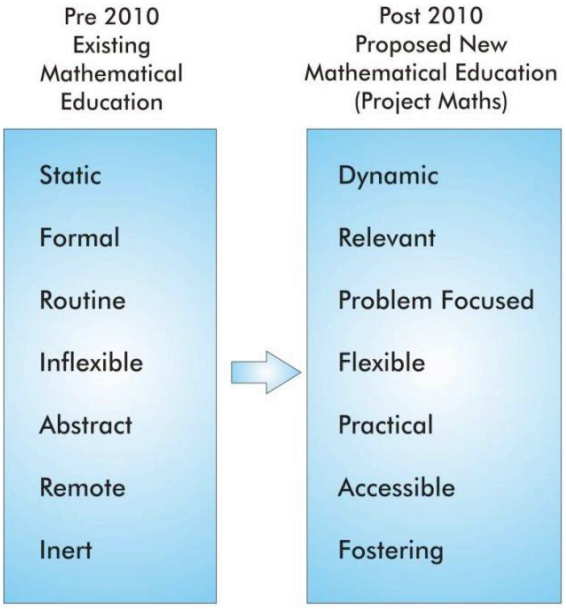
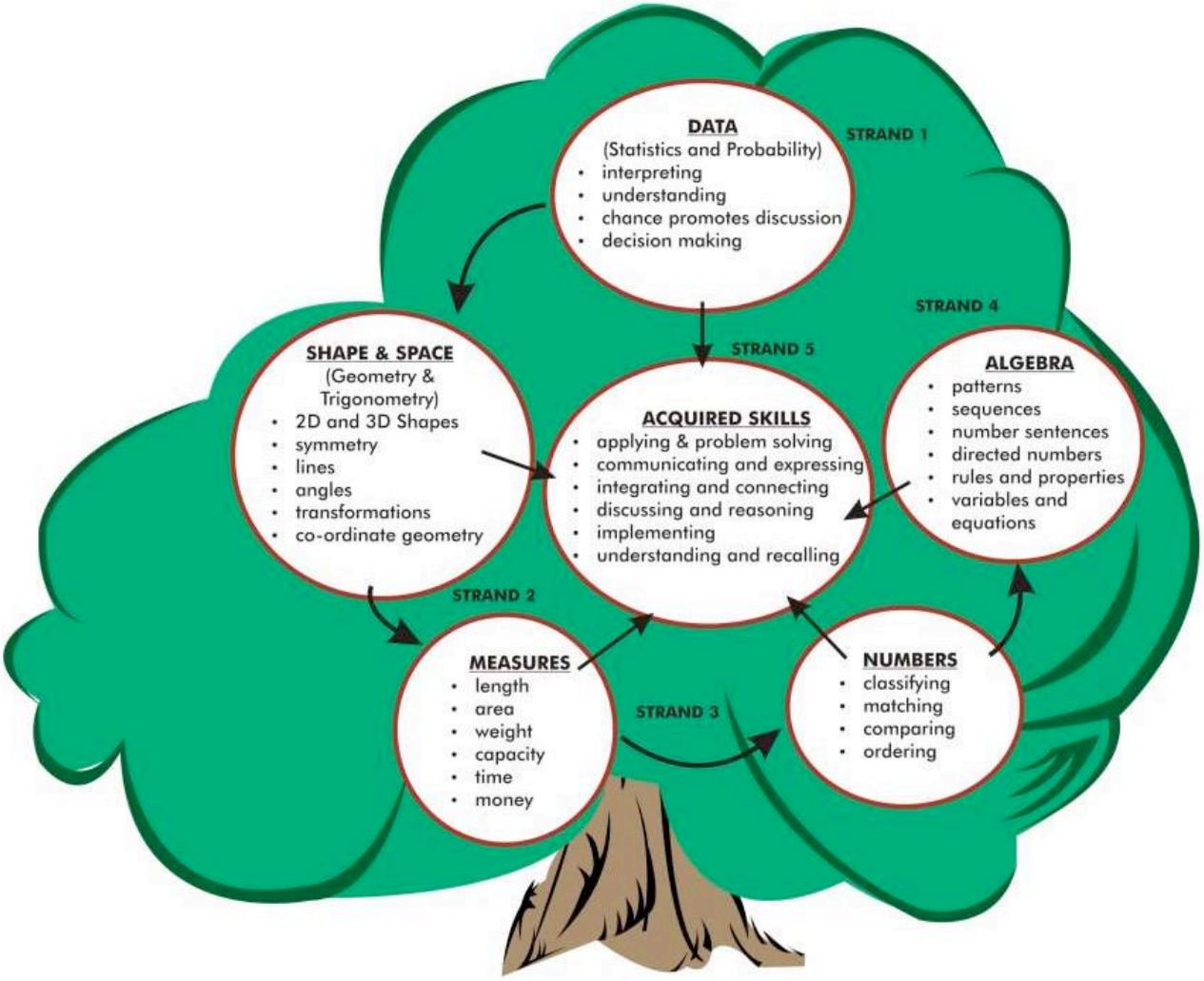


Figure 22 - Structure of New Project Mathematics Curriculum



Chapter 4 Proposals for Performance Improvement

Based on our analysis of the current state of Mathematics and Science Education at Second Level Engineers Ireland make the following Proposals for national performance improvement:

Proposal 1 – Support Project Maths and Ensure Adequate Resourcing

The advancement of national economic objectives requires a more holistic approach to the education of Mathematics and Science using the Project Maths model currently being introduced by the NCCA. However this new venture towards improved national mathematical competence needs better investment in terms of resource materials and CPD teacher training to expedite successful outcomes as it could take a full generation to embed it in our educational system. We support the proposal to give every Mathematics teacher 10 days of in-service CPD training within the phased rollout. Also a stronger focus on the new curriculum for Junior Cycle is needed as this is where the principal problem lies with Mathematics as well as in the Senior Cycle.

Proposal 2 – Make Science Compulsory at Junior Cycle

The importance of Science subjects to the future 'knowledge economy' is such that Science needs to be made a compulsory subject at Junior Cycle Level as is the case in the vast majority of EU countries. This needs to be complimented immediately by a stronger focus on Science and also Mathematics at Junior Cycle.

Proposal 3 – Ensure Maths Teachers are Adequately Qualified to Teach

The teaching of Mathematics at Second Level should require a degree or post graduate diploma in Mathematics and adequate education qualifications for all existing teachers in addition to new entrants. The current BA in NUIG in Mathematics and Education and MSc in Mathematics Education in NUIM should be extended by a combination of e-learning (from NUIG) and initiatives of similar courses in Dublin and Cork. This may require further resources, which could be achieved through potential collaboration with the National Centre for Excellence in Mathematics and Science Teaching & Learning in UL as well as other strategic partnerships. Similar courses in the Mathematics and Science Education area are also offered by NUI Maynooth and Dublin City University in the Dublin region. Existing teachers should be required to engage in accredited CPD courses approved by the Department of Education and Science and encouraged to avail of the many resources and support programmes offered by the NCE-MSTL. There is also the potential to equip engineers who desire a 'career change' with the necessary educational skills to teach Mathematics in a very contextual and practical way and in the meantime to act as "facilitators" which are current vacancies recently advertised by the NCCA.

Proposal 4 – Ensure Science Teachers are Adequately Qualified to Teach

The teaching of Science at Second Level should also require a degree or post graduate diploma in the relevant Science subject together with adequate teacher education qualifications. Similarly Chemistry, Physics and Applied Mathematics teachers at Second Level should have degrees in these respective fields.

Proposal 5 – Use the Power of ICT to Teach and Learn Better

The use of ICT and video needs to be significantly improved to assist and support the new Mathematics and Science curricula. This will aid the visualisation and understanding of the most abstract concepts. This also requires the provision of adequate CPD training for those many teachers with low IT literacy. In particular, as part of the 'innovation' drive to the 'smart economy' a key incentive should be the creation of inventories of ICT based systematic thinking and tools summarily described under the heading of TRIZ. There are also online aids to learning available which could also be assisted by Engineers Ireland (e.g. Reachateacher.ie).

Proposal 6 – Incentivise Teachers and Students

The improved teaching of Mathematics should be incentivised through the award of scholarships and prizes to "teachers of outstanding merit" in addition to the award winning students, e.g. Engineers Ireland should consider awarding an annual prize at the BT Young Scientist Exhibition for an outstanding project based on Project Maths.

Proposal 7 – Have Consistent Quality Tests at End of Primary

There needs to be a consistent national assessment test through continuous assessment or otherwise to determine the standards of mathematical competence at the end of Primary school as the lack of consistent standards in First Year Junior Cycle is endangering the necessary uplifting of standards at Junior Cycle.

Proposal 8 – Use Transition Year to Encourage Maths and Science

Transition Year should be more encouraged at Second Level and the percentage and scope of the mathematical content of Transition Year's work upgraded to make a most meaningful contribution to Project Maths and Science subjects. More project work in Mathematics Science and Technology should be encouraged during Transition Year.

Proposal 9 – Better Linkage Needed Between Primary and Second Level

There needs to be greater 'joined up' thinking between Primary and Second Level Mathematics and Science as currently there are insufficient linkages. The new common first year course for Project Maths needs a strong implementation focus to correct current deficiencies. Linkages must also extend to Third Level with particular emphasis between Third Level Engineering degrees, higher certificates from Institutes of Technology and Leaving Certificate. Both linkages need strong promotion from the NCCA and Universities Ireland/Institutes of Technology.

Proposal 10 – More Career Guidance Needed on STEM Careers

There appears to be a lack of appreciation in the Career Guidance Profession of the need to ensure high uptakes of good quality graduates in Science, Engineering and Technology courses and to support and encourage the national efforts to rebuild a smart economy and assist natural recovery. One reason for this is that too few career guidance professionals come from the Maths Science and Technology areas. The Career Guidance Profession should examine the situation further.

Proposal 11 – Overhaul and Integrate Applied Mathematics in New Approach

The Applied Mathematics syllabus requires an urgent overhaul in line with the Project Maths model. Applied Mathematics needs to be promoted as a practical example of how Mathematics is relevant to problem solving in Engineering, Science and other Technology courses. There is a need to increase the number of schools who offer this subject particularly in girl schools. The issue of adequate teacher resources and CPD needs to be addressed. Also consideration needs to be given to altering the name of this subject to Engineering Mathematics.

Proposal 12 – Implement 'Tax Breaks' for Teacher Retraining

The Government should examine the possibility of 'tax breaks' for Mathematics and Science teachers who register for full time retraining and CPD in NUI Galway, UL, NUI Maynooth, DCU or similarly approved specific courses in the subjects of Mathematics and Education. This will be a positive step towards the national 'smart economy'.

Proposal 13 – Ban Calculators at Primary and Junior Cycle

The reliance on calculators in Early School interferes with the child's ability to appreciate numbers and appears to lead to a general decline in some aspects of numeracy. Thus their use should be banned or withdrawn by the Minister in Primary and Second level up to and including Junior Certificate.

Proposal 14 – Better Resource Laboratories at Second Level

There needs to be continued resourcing at a significant level for the provision of Science laboratories in Second Level schools nationally. In addition the proper introduction of the new Project Maths will need new resource accommodation labs or libraries for ICT, video and other resources.

Proposal 15 – Appoint 'Head of Subject' in Each School

Second level schools should identify 'curriculum champions' in each school who would be 'Head of Maths' or 'Head of Science' and who would specialise in ensuring that all teachers in that area would be fully conversant with curriculum changes as they arise and lead in terms of teaching policy in that school for that subject.

Proposal 16 – Give More Teaching Time to Mathematics

The amount of classroom time allocated to the teaching of Mathematics at Primary and Second Level needs to be increased. In recent years the amount of time allocated to Mathematics has been reduced at these levels particularly at Junior Cycle due to an expanded curriculum. At least one class period a day should be allocated to the teaching of Mathematics at Second Level in each school.

Proposal 17 – Investigate Failures at Ordinary Level Leaving Certificate Maths

There needs to be a thorough examination into the failure rates at Ordinary Level Leaving Certificate Mathematics as these high failure rates are having a serious impact on the quality of mathematical competency of those entering Level 6/7 institutions.

Proposal 18 – More Schools Need to Offer Higher Level Maths

There is a need to increase the number of schools that currently offer Higher Level Mathematics. Many schools are unable to offer this as only a minority of students wish to take Higher Level and schools cannot afford to designate a teacher to just a few students. This proposal will only work if we incentivise student interest and demand for Maths and Science through curriculum change and exciting new teaching methods.

Chapter 5 Actions

Having regard to our research to date Engineers Ireland commit to the following in terms of the assistance and support we can give to the better education of Mathematics and Science at Second Level:

Action 1

That Engineers Ireland as the authoritative voice of Irish Engineering and as a leading professional group in the 'knowledge economy' seek a voice in the NCCA in the future direction of curriculum change in subjects relevant to our profession at Second Level i.e. Mathematics, Applied Mathematics, Physics and Chemistry and in implementation groups with this purpose.

Action 2

That Engineers Ireland offer award incentives to teachers to retrain and up-skill to meet the challenges of new syllabi in Mathematics and Science subjects. These incentives could take the form of sponsored scholarship schemes or alternative award schemes for 'outstanding merit' including the BT Young Scientist Awards.

Action 3

Due to the current downturn in the construction industry, advantage could be taken of retraining engineers as Mathematics and Science teachers. This is subject to them acquiring an acceptable post graduate degree or diploma qualification in Education similar to the new NUIG, UL, DCU and NUIM Mathematics and Education degrees and support courses in DIT, CIT & WIT. Engineers Ireland must encourage and promote this development with the Teaching Council and NCCA and seek possible tax breaks for the retraining of personnel.

Action 4

Engineers Ireland need to awaken greater interest in Project Maths/Science at both Primary and Second Level by better integration into the STEPS Programme to ensure more holistic and integrated learning towards Engineering and Science subjects and with particular regard to Transition Year teaching and students. The STEPS Programme should be re-examined and strengthened to help fulfil the Engineers Ireland recommendations in this report.

Action 5

Engineers Ireland should lead a greater use of the power of ICT to contextualise the teaching of Mathematics and Science at Primary and Second Level.

Action 6

Engineers Ireland should set-up on our new website a Wiki-Solution web page to assist students with problem solving in Mathematics and Applied Mathematics and link with other relevant sites.

Action 7

Engineers Ireland should consider setting up a new Education Division to attract Third Level professors and lecturers in Mathematics, Science and Engineering to join and participate in greater numbers. We should also include Primary and Second Level teachers at meetings on a regional level to aid improved communication between teachers and engineers on a professional level. The essential continuity links between Primary and Second Level need to be emphasised in these regional 'conversations'.

Action 8

There needs to be more formal links between Engineers Ireland and Women in Technology and Science (WITS) to ensure greater gender integration in Mathematics, Science and Technology courses.

Action 9

The rising failure rates at Ordinary Level Leaving Certificate Mathematics must be urgently examined as it will seriously impact on the future standard of technicians (Level 6/7) in Ireland.

Action 10

There is a significant opportunity for interactions in Transition Year by Engineers Ireland. We must make it more practical with topical projects within the Project Maths, Science and Engineering fields. There are great future opportunities for Engineers Ireland to link with Second Level schools, Teacher Associations/Unions and Industry to assist further the development of the 'smart economy'.

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Appendix A Membership of Engineers Ireland Taskforce and Peer Reviewers

TASK FORCE

Membership of Task Force on the Education of Mathematics and Science at Second Level

Mr. PJ Rudden*, Group Director RPS and Vice President Engineers Ireland (Chairman);

Dr. Jim Browne*, President NUI Galway and Immediate Past President of Engineers Ireland;

Mr. John Carley*, Director of Environment & Water Services, Carlow County Council;

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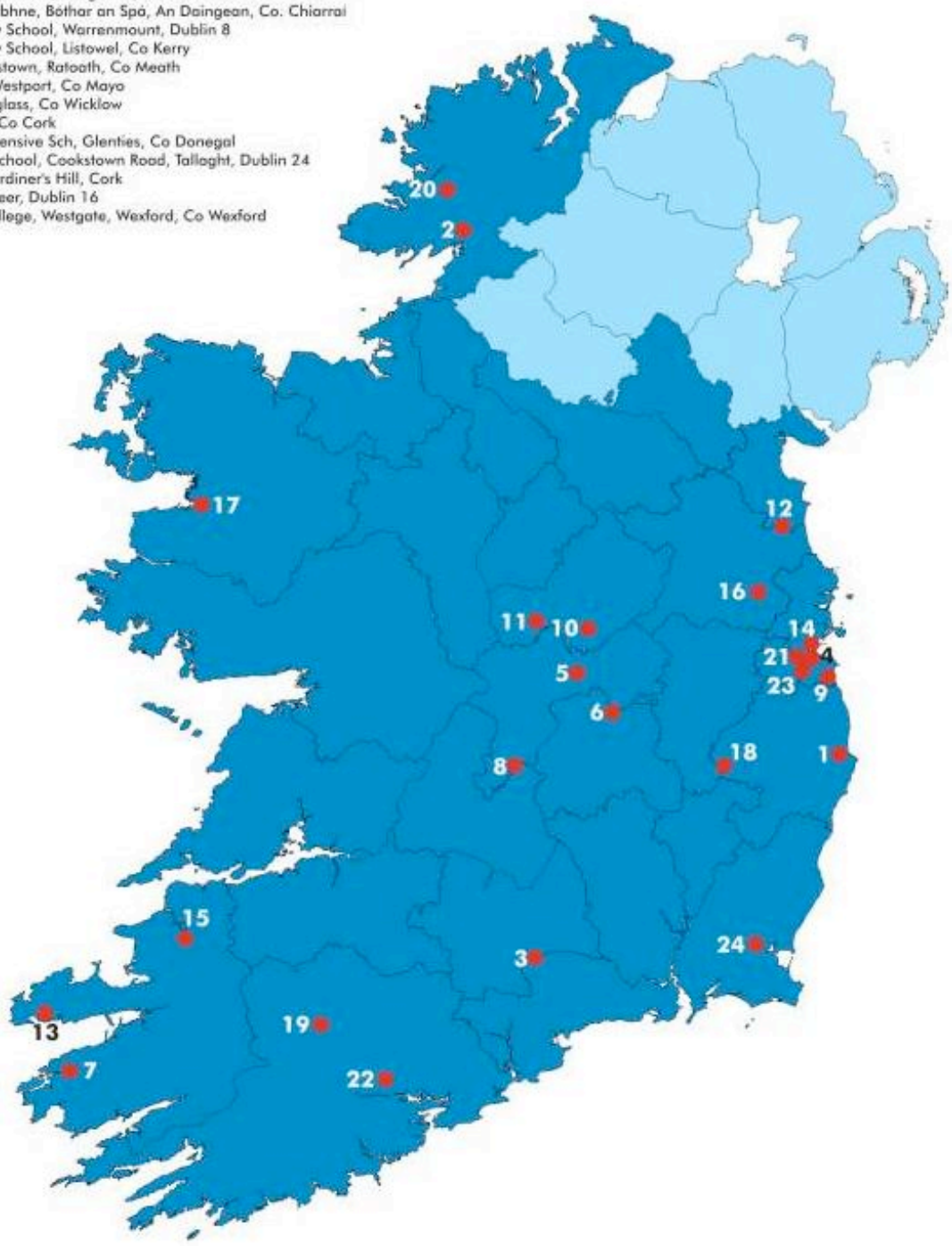
Appendix B Project Maths – Initial School Locations

PROJECT MATHS

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

Schools participating in Project Maths

1. Abbey Community College, Wicklow, Co Wicklow
2. Abbey Vocational School, Donegal Town, Co Donegal
3. Ardscoil na mBráithre, Clonmel, Co Tipperary
4. Castleknock College, Castleknock, Dublin 15
5. Coláiste Choilm, O'Moore Street, Tulach Mhór, Co Offaly
6. Coláiste Íosagáin, Portarlington, Co Laois
7. Coláiste na Sceilge, Caherciveen, Co Kerry
8. Coláiste Phobal Ros Cré, Corville Road, Roscrea, Co Tipperary
9. Loreto Abbey Secondary School, Dalkey, Co Dublin
10. Meán Scoil an Chlochair, Kilbeggan, Mullingar, Co Westmeath
11. Moate Community School, Church Street, Moate, Co Westmeath
12. Our Lady's College, Greenhills, Drogheda, Co Louth
13. Pobalscoil Chorca Dhuibhne, Bóthar an Spá, An Daingean, Co. Chiarraí
14. Presentation Secondary School, Warrenmount, Dublin 8
15. Presentation Secondary School, Listowel, Co Kerry
16. Ratoath College, Jamestown, Ratoath, Co Meath
17. Sacred Heart School, Westport, Co Mayo
18. Scoil Chonglais, Baltinglass, Co Wicklow
19. Scoil Mhuire, Kanturk, Co Cork
20. St Columba's Comprehensive Sch, Glenties, Co Donegal
21. St Mark's Community School, Cookstown Road, Tallaght, Dublin 24
22. St Patrick's College, Gardiner's Hill, Cork
23. Wesley College, Ballinteer, Dublin 16
24. Wexford Vocational College, Westgate, Wexford, Co Wexford



Appendix C List of Consultees

Consultees were either asked for their views prior to Report preparation and /or asked to comment on a Draft version but did not write any part of it

Mr Peter Brabazon – Discover Science and Engineering, Forfás;

Dr. Sinead Breen – St. Patrick's College, Drumcondra;

Mr. Michael Carr – School of Engineering, DIT;

Mr. Kevin Conliffe – Association of Applied Mathematics Teachers of Ireland;

Mr. Eddie Conlon – School of Science, DIT;

Dr. Frank Devitt – School of Education, NUI Maynooth;

Ms. Cammie Gallagher – Project Maths Teacher;

Mr. Eoin Gill – School of Engineering, Waterford IT;

Dr. Tony Hall – School of Education, NUIG;

Ms. Catherine Hickey O' Maolain – Deputy Principal Coláiste Iognáid, Galway;

Dr. Kevin Jennings – Mathematics Lecturer, NUIG;

Mr. Joe Kindregan – School of Engineering, DIT;

Dr. Liam McNiffe – Principal, St. Patrick's College, Cavan;

Dr. Gerry Morgan – Dean of Science, NUI Galway;

Dr. Brien Nolan – Education Dept Dublin City University;

Ms. Elizabeth Oldham – School of Education, TCD;

Professor Eugene O'Brien – School of Engineering, UCD;

Professor Padraic O'Donoghue – Dean of Engineering, NUIG;

Professor Philip O'Kane – School of Engineering, UCC;

Professor Margaret O'Mahony – Bursar and School of Engineering, TCD

Dr. Ann O' Shea – Department of Mathematics, NUIM;

Dr. Aiden Seery – Trinity College Dublin;

Ms. Michelle Starr – NCE-MSTL, University of Limerick