

DECIPHERING THE EFFECT OF CURRICULA ON THE PERCEPTION OF THIRD LEVEL ENGINEERING – A COMPARATIVE ANALYSIS

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Abstract: Recent PISA surveys have shown that Ireland's relative ranking in Mathematics has fallen sharply, while Finland maintains its position at the top of the international table. Simultaneously, Ireland is experiencing a shortage of engineers and falling/static demand for engineering programmes, in common with many Western economies, while Finland maintains both a strong public image of the profession and a sufficient supply of able students into university.

The recent economic woes experienced in Ireland have thrown the difficulties in the STEM area into sharp focus, and there is, at least currently, a momentum for change in the education system. With Finland having successfully progressed through a similar crisis in the 1990s, and having transformed its education system, it seems appropriate to examine what lessons can be learned.

The structure of the education system at secondary level in both countries, with particular focus on the STEM area, is compared and conclusions are drawn with regard to the relative performances in the PISA scores and the public perception of the profession, including its effect on student recruitment.

Keywords; engineering education, economic growth, academic structure, society, perception.

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1. INTRODUCTION

Since the 1990s, the Finnish education system has become famous for its successful restructuring. A significant aspect of this international recognition is that the change can be viewed not only as an educational overhaul but as a cultural reconditioning, influencing not only education but the economic growth of the country itself. The primary focus of this reformation was a restructuring of the country's education system from the classroom level upwards – a decentralisation of curriculum management (Rinne et al, 2002).

This paper aims to present a case for the link between the engineering and education sectors and economic growth, highlighting the necessity for cooperation between engineering education and society as a whole – as society's perception of engineering influences those interested in studying in the field. Ireland currently has a distinct shortage of engineers (Engineering a Knowledge Island 2020, 2005), but can learn from the Finnish situation from both a governmental and pedagogical perspective.

2. PERCEPTIONS OF ENGINEERING

While once highly regarded amongst professions in Ireland, the public perception of engineering has dropped within the past decade. This decrease in interest has been reflected in the number of students portraying interest in studying engineering at third level. Figure 1 shows the percentage of student applicants to a selection of the most popular sectors of third level study – it can be seen that the numbers of students pursuing study in the field of engineering and technology has been steadily decreasing since the early 2000s.

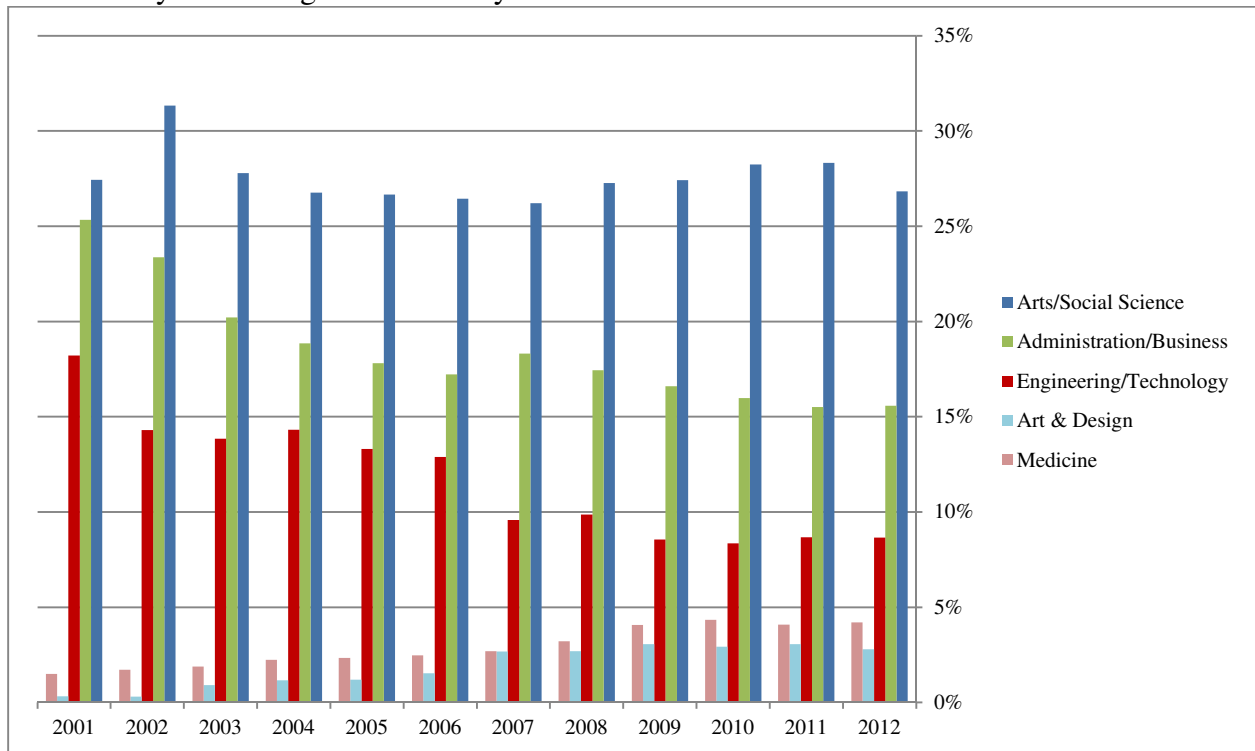


Figure 1: Irish student application for third level study by sector

Irish students usually complete this application process during the final year of their study at second level, and as such it can be assumed that their decision is at least in part influenced by their experience during the course of their second level education.

Throughout primary and second level education, students primarily experience a transmittal form of education across the STEM field. Students receive very little opportunity to develop an association between the knowledge they are accumulating and its application to real-world situations. While students are provided with laboratory and project work, it is typically presented in a highly constrained manner – accompanied with step-by-step instructions and little opportunity for research/discovery. Consequently, students develop from an early age the opinion that engineering is a “desk job” in which employees are expected to solve prescribed mathematical equations, instead of the creativity, team work and hands-on design which are arguably more representative of the field. Young people are not provided with the opportunity to create a mental link between, as examples, the algebra they are learning and the design of a cellular phone, or trigonometry and the design of a car engine. Ultimately, the public’s perception of the field of engineering can be clearly seen from dropping rates of applications from second level students to study in the field – indicating a decrease in overall interest levels in

the sector. In Finland, however, extensive and continuous effort has been placed into monitoring the nation’s perception of the field of engineering. Interest in study in the field has been continuously underlined in high levels of yearly study applicants. The Finnish Association of Graduate Engineers (TEK), alongside the Technical Research Centre of Finland (VTT), have developed a “Technology Barometer “ – aimed at maintaining a record of the nation’s techno-scientific state and the public’s opinion of the technology sector. Results from this study in the past decade have shown that young students’ opinions of the field of engineering remain high. The professions of “engineer” and “businessman” were found to be the considered the most attractive professions for young people in a survey in 2009 – a stark contrast to the situation in Ireland.

1.1 Efforts to improve the perception of engineering

Extensive investment has been made in programs to attract primary and second level students to the study of STEM subjects at third level education in Ireland. Initiatives such as STEPS (a campaign run by Engineers Ireland), TrinityHaus (Trinity College Dublin), and Discover Science & Engineering (Science Foundation Ireland) host numerous events and demonstrations across the country each year with the purpose of presenting a hands-on introduction to engineering and science for students. While these events do fulfil the purpose of exhibiting to students the practical nature of the sector of engineering to students, it does not totally eliminate the nation’s negative perception of engineering. In order for students to become motivated towards the area of engineering study, it is necessary that these displays be integrated with the education syllabus. Within Ireland’s second level education system, students may choose between three streams of mathematics education:

- Ordinary level provides a basic standard of mathematics education
- Foundation teaches to a lower standard – for those who would have particular difficulty in studying the field of maths
- Higher level maths encompasses a more advanced level of mathematics education, and is a requirement for entry into most third level engineering courses in the STEM field, especially engineering.

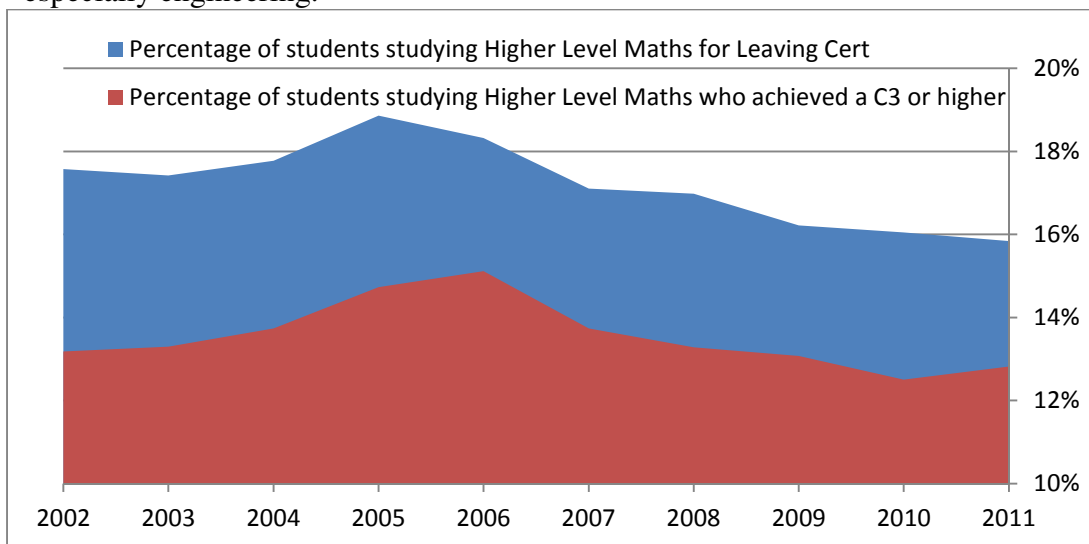


Figure 2: Percentage Irish students studying Higher Level Maths for their matriculation exams

During the course of second level education in Ireland, students complete two standardised sets of examinations. The 'Junior Certificate' exams mark the end of compulsory education at age 14 (see Fig. 3), while the 'Leaving Cert' exams are taken at the end of secondary education at age 17. The above graph, Fig. 2, shows the percentage of the total student population completing the Higher Level Maths course for the Leaving Certificate. Presumably due to the mathematical aptitude required in the study of engineering, 81% of the degree-standard engineering courses across Ireland require that students achieve a minimum of 55% in their Higher Level Maths final exams. The percentage of students achieving this standard each year is also shown on the graph in Fig. 2. However, due to the presence of this formal barrier, there is a significant portion of the Irish student body is being prevented from choosing engineering – reducing the attraction pool to which engineering courses may market to approximately one tenth of the high school leaving cohort.

In Ireland, reform has already commenced in the field of STEM education with the introduction of the new mathematics syllabus, Project Maths. This new curriculum introduces the practical nature of maths, and allows teachers to introduce students to the everyday necessity that is mathematics. Areas such as geometric construction, graphical representations and finance are highly emphasised through the Project Maths course, increasing students' motivation for study.

3. IMPACT OF ENGINEERS ON SOCIETY

While recent economic growth in Ireland has been largely influence by sectors such as property construction and services, incentivised by low taxation, it is generally accepted that future growth will not be able to depend as strongly on these sectors. According to Sahlberg's 2007 report, Education Policies for Raising Student Learning, the backbone of Finland's continued economic growth resided in the fact that it had become a knowledge economy. In the 1960s, most students in Finland had completed only their compulsory, primary level education – whereas by the 2000s, most students were moving on to complete third level education. This provided them with the skills and knowledge to fuel the research and development sector, which in turn pulled in industry and commerce looking to employee graduates from the STEM field – resulting in an overall increase to the economy's strength.

The 2005 report, Engineering a Knowledge Island 2020, highlights the relationship between the expansion of Ireland's engineering industry and the nation's economic growth, citing the positive impact made in the past by sectors such as high-technology manufacturing through research, development and innovation. But although employment within the Irish engineering sector has been steadily rising – from 19k workers in 1991 to over 40k by 2001/2002 – there is an insufficient number of engineering graduates being produced in order to fill this rising demand.

In March 2011, John Power – Director General of Engineers Ireland – stated at the Engineers Ireland Annual Conference: 'There are currently 1,200 engineering vacancies across Ireland in the pharmaceutical and biomedical sectors which companies cannot fill, in a country that presently has over 430,000 people unemployed, this is a remarkable figure. It is clear that, whether it is associated with the field itself or the manner in which engineers are educated, there is a problem with the perception of engineering within Ireland.'

In order for the expansion of the engineering sector to continue, Ireland must ensure the continuous production of highly skilled engineering graduates from third level institutions.

4. EDUCATIONAL STRUCTURE AND REFORM

Several contrasts can be drawn between the structure of the education system in Ireland and that implemented in Finland, including students’ exposure to learning – both in the form of Montessori-style development of the psyche, and their experience with formal education.

The term Montessori education serves to reference a particular pedagogy most commonly geared towards younger children, in which the students’ individualism, creativity and psychological development are emphasised. The backbone of the Montessori model holds strong with progressive practices –with dynamic lesson models rooted in constructivist and constructionist theory.

Only 200 Montessori schools currently operate within the Republic of Ireland. Within Finland, however, children’s introduction to the education process is approached with wholly different fundamental end-goals. While compulsory education within the Finnish state doesn’t commence until the age of 7, most children – an average of 83%, according to OECD 2011 – are enrolled in one of the country’s Early Childhood Education and Care (ECEC) programs; a state-run program of childcare and education introduced in 1996 and offering a curriculum for all citizens between the ages of one and six. The ECEC system is designed towards the completion of two primary goals - providing a service of child day-care, and the introduction of a strong grounding of psychological and educational development for the child in question. ECEC programs aim for this primarily through the implementation of highly educated teaching professionals – with the requirement for all staff to have at least a second level degree in the field of health care and social welfare – and a goal-orientated environment of active learning.

Overall, the structural design of the Finnish education system provides for a far longer period of personal development for the student, due to a decrease in the number of years the student is required to spend in compulsory education. When compared to the Irish education system, as in Fig. 3, it is clear that there is a significant difference in the overall number of years that Finnish students are required to spend in formal education when compared with the average Irish student.

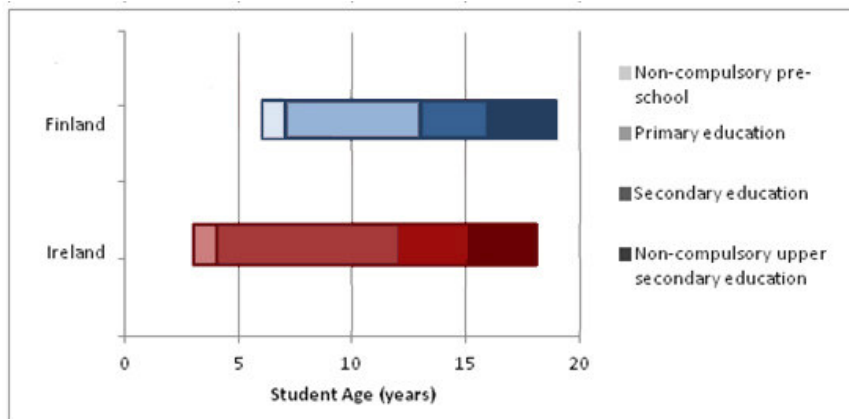


Figure 3: A comparison of primary/secondary educational structure

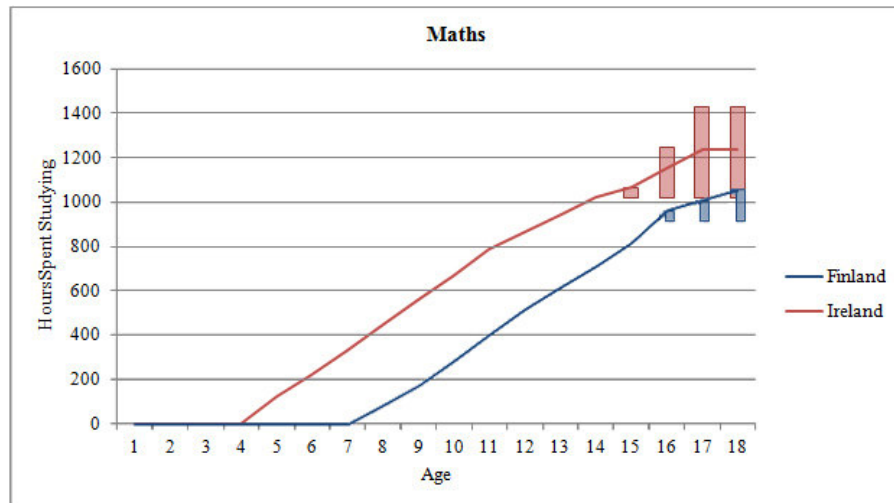


Figure 4: Cumulative hours spent studying maths

Furthermore, as shown in Fig. 3, Finland not only presents a significantly smaller number of hours of compulsory education to the country's citizens, Finnish students also spend an fewer hours overall in the study of STEM subjects and mathematics. In the graph shown in Fig. 4, the lines represent the weighted average of the number of hours studied by students within each country across the years. The bars in this graph represent the minimum to maximum number of hours a student may spend studying the subject when the option is available to them, most notably towards the end of their second level education when they begin to specialise.

This new structural design allows for a decrease in spending on resources associated with formal education. Through the removal of formal evaluative procedures within the education system – such as end-of-year exams, and school inspections – learning is no longer geared towards the ideology of the end-goal of exam results. This is true for both the students and teaching professionals. The focal point of academic life has instead been moved to the personal development of the student – as shown through the significant decrease in the number of years compulsory for formal education, with these years devoted instead to the ECEC.

5. EXTERNAL ACADEMIC EVALUATION

Not only is Finland's educational revamping to be considered a success from the standpoint of its immensely positive economic effects, the country has also enjoyed international acclaim for its new academic system. From teachers' satisfaction with the curriculum to student competence, numerous sources have cited Finland amongst the world's top countries with regard to their education structure.

An institution of academic appraisal, the International Association for the Evaluation of Educational Achievement (IEA), has provided data to form the basis Finland's educational progress. Commencing their study of Finland in the early 1980s as the (Second) International Mathematics Study (SIMS), the IEA ranked Finland's mathematical literacy as of average stature (with regards to the international community) when considering academic achievement, curriculum structure and student competency. A further study was made through the recapitulation of the Third International Mathematics and Science Study (TIMSS-R), finding the newly revamped Finnish system to rank above the international average – a progression

underlined during the first Programme for International Student Assessment (PISA) testing of 2000. Throughout the application of the PISA rankings, one of the most notable international rankings of educational achievement, Finland has maintained a place within the top countries in the world with regards to verbal literacy and – most importantly for our considerations – also within mathematical aptitude. Within this assessment, OECD countries are called upon to draw a minimum randomised sample of 5,000 students to be surveyed academically. Students are surveyed on factors such as personal background, learning habits, their attitude towards education as well as completing a cognitive test – aimed at gauging their competency in the desired field.

6. DISCUSSION

Engineering sectors, such as manufacturing, have been demonstrated to have a significant impact on sustainable economic growth within a country (Sahlberg, Engineering a Knowledge Island 2020). But the expansion of the engineering sector relies on the input of both industrial investment and a continued influx of qualified engineers – thus highlighting the relationship between economic growth and the output of engineering graduates from third level institutions. But even with the high employability of engineers across Ireland, the number of students choosing to study in the field of engineering is decreasing – resulting in a deficit in the number of engineering graduates in Ireland for the industry’s requirements. This factor is affected by the poor public perception of the engineering field in Ireland, resulting in part from a low level of awareness of what is involved in an engineering career. This low perception can also be partly attributed to policies which exist within the Irish education system. Students receive their STEM education through a primarily transmittal approach, without sufficient emphasis on the relationship between the theory they are absorbing and its practical application within real world devices. The newly introduced Project Maths syllabus attempts to amend these deficits through an innovative curriculum underlining the importance of skills such as problem solving for practical assignments. It is early days yet for the Project Maths course and, pending a formal evaluation, its success is yet to be determined. But yet there is also insufficient importance placed on the link between STEM careers and skills such as public speaking, writing, and teamwork.

Finland’s path to economic recovery through educational reform provides an important case study upon which Ireland may model a similar return to economic expansion. When the Finnish economy entered a depression during the early 1990s, the country held a population of just under five million – only slightly higher than Ireland’s population at the beginning of their economic downturn at the end of the 2000s. Similarity of the two nations also extends to the deficit in engineering graduates industries across each country were experiencing.

In order to combat the country’s struggling economy, Finland embarked on a reformation and improvement of the national education system:

a. Decentralisation

Commencing with a decentralisation of the administrative process for educational institutions, Finland provided individual establishments with the ability to function in a manner to best serve their specific situation and local needs – facilitating the development of specific coursework or partnerships with industry.

b. Increased emphasis on soft skills required for work within the field of engineering

The decreased number of years considered compulsory education did not disincline Finns from enrolling students in non-compulsory education, with 83% of families availing of the service.

Students experience an education focused upon areas such as teamwork, communication and ethics – skills imperative for the study and practice of engineering.

Finnish students were now being exposed to an informed and balanced view of the multi-faceted engineering field and consequently the public perception of engineering improved – a factor important for the attraction of future engineering graduates.

It can be recommended that Ireland follow the example of Finnish economic recovery through the reform of the education sector.

- Using a policy of decentralisation, Ireland can increase innovation and creativity within the design and implementation of STEM curricula. Presenting an accurate depiction of the practical and multi-disciplinary nature of the engineering field is important to both the attraction of future engineering graduates and the retention of STEM students at secondary level education.
- Taking steps to increase the public awareness of engineering and to improve the nation's perception of the sector can serve to combat the decline in students applying for study in the field. An increase in the number of skilled engineering graduates within Ireland can cause an increase in the output from research, development and innovation – therefore attracting industrial investment in the nation.

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