MATHEMATICAL EDUCATION

The Dynamic Role Of Mathematics In Business

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Where did it all begin?

Historians claim that mathematics can trace its origins back about 6,000 years to the Middle East. The Babylonians and the Egyptians used elementary mathematical applications in their everyday life. Mathematics was a key element in the early application of science by the more advanced among the prehistoric people who were curious enough to try to ascertain the workings of the world around them. The Egyptians are probably the first recorded people to have used arithematic and geometry perhaps as long ago as 4,000 B.C. and this led to the Egyptians developing expertise in areas such as civil and structural engineering, medicine and astronomy. The Greeks made many advances on the intellectual side of geometry, physics, astronomy and biology.

Mathematics was used in ancient times not only for intellectual and scientific pursuits but also for accounting purposes. The Egyptians considered this

task so important that they entrusted the keeping of accounts to a hereditary class of scribes.

A historian could undoubtedly trace the history and development of mathematics from the early times of Babylon, Egypt, Greece, Rome and Byzantium through the Dark Ages to the new beginning from about the fifteenth century onwards. The new beginning in a commercial sense owes a lot to the Italians who set about the problems of keeping accounts, calculating compound interest and solving insurance problems which were part and parcel of their growing international trade. It is at this stage that we meet the man who is acclaimed as the Father of Accountancy — an Italian Franciscan friar, Luca Pacioli — who is credited with the publication in 1494 of a book on algebra and who is also revered as the Father of Double Entry Book-Keeping.

Economic development is the key

The major motivating force in the development of mathematics from the earliest stages seems to have been a desire by man to understand the workings of the world about him and to harness those workings to improve his own well-being. In modern language, the desire would be expressed as a desire to earn more jobs and higher living standards. Modern man would probably claim that the motivating force for scientific discoveries, including mathematical discoveries, is ultimately that of economic development. This can be brought up-to-date in terms of the Programme for the Completion of the EC Internal Market by the end of 1992. One of the primary objectives of the integration of the economies of the 12 Member States of the EC is to strengthen the EC's capacity in science and technology. This is to meet competition in the international marketplace mainly from the USA, Japan and some of the dynamic emerging nations in the Pacific basin.

Science and Technology is an area in which Ireland can fully participate in the completion of the EC Internal Market and in which we can gain a major advantage because of our highly qualified and well educated workforce. It is also an area in which there can be even greater partnership between education and industry. This partnership needs to be founded to a far greater degree on the reality that it is the *business enterprises* in both the private and the public sectors which *transform scientific and technological knowledge and advancement into economic and social progress.* In other words, it is the private and public sector enterprises which provide the mechanism whereby

the work in the schools, colleges and universities is ultimately translated into viable long-term jobs and higher living standards for the entire community.

The challenge to Ireland

The National Development Plan 1989–1993 which was submitted by the Irish Government to the EC Commission on 22nd March 1989 and published on 31st March 1989 acknowledges that the Irish GNP per capita measured in current prices and purchasing power standards amounted to only 58% of the EC average in 1987. The problems in Ireland are accentuated by high unemployment and by a demographic structure which results in a high dependancy ratio. Unemployment is currently more than 17% in constrast to the EC average of less than 11%, and Ireland is second after Spain in the high unemployment league.

Ireland's present situation poses an enormous challenge. An increase in living standards and a fall in unemployment will both depend upon economic development. In order to achieve higher living standards and provide more jobs, it is essential to increase the output and added-value of goods and traded services which are produced by private and public enterprises. There is no escaping the reality that Ireland must and can achieve a far higher level of industrial and commercial output. This places an emphasis on competitiveness in terms of the general environment for enterprise, in terms of specific business input costs, in terms of innovation and in terms of management expertise. The main focus must be upon making optimum use of our natural resources with particular reference to our high quality workforce. In this context, the Confederation of Irish Industry in a number of submissions made to the Government as part of the consultative process for the preparation of the National Development Plan 1989–1993 sought significant up-grading in the following areas of public economic infrastructure — transport, energy, education and training, environmental services and telecommunications. The Confederation of Irish Industry also sought infrastructure investment related to three major areas of natural resource development — the food industry, forestry and tourism.

Skills of people

There is a growing emphasis on developing the skills of Irish people in various internationally traded service areas such as finance and consultancy. These are areas in which Ireland does not necessarily suffer from the infrastructure cost disadvantages which attach to the development of heavy manufacturing industry on a broad basis in a small island nation. An emphasis is being placed on computer services, data processing, health services, educational services, and architectural and engineering consultancy as well as on an extremely wide range of financial services activities. The engineering and applied science emphasis is on high technology and high added-value areas which tend towards the arena of skills and software rather than towards bulk materials utilisation. The greater emphasis on high technology and the utilisation of high level skills is already bearing fruit in manufacturing industry which is reporting strong demand for engineers, computer, marketing and financial staff.

Mathematical awareness

Mathematics has a key role to play in the development of a modern high technology economy. It is essential to create an awareness of the value of mathematics not only as an intellectual discipline in itself but also in terms of its contribution to the generation of higher living standards and more jobs. A discussion document issued by the Curriculum and Examinations Board (now the National Council for Curriculum & Assessment) in November 1986, was entitled "Mathematics Education: Primary & Junior Cycle Post-Primary" and this contained a clear set of desiderata for mathematics teaching and a syllabus content which, if realised, would lead to a wonderful increase in the level of mathematical awareness in society. It is vital, in this context of awareness creation, that mathematics be presented in as attractive and stimulating a way as possible to young people in their early formative years.

Securing the educational base

The Confederation of Irish Industry believes that in order to optimise the contribution which mathematics can make to the development of the economy, it is essential to provide a very secure base in terms of mathematical education at the junior cycle level. The Confederation made a submission to the Syllabus

Committee for Mathematics of the Department of the Education in May, 1983. The recommendations contained in that submission are as valid to-day as when they were first made. A repitition of those recommendations here will give a comprehensive view of the attitude of industrialists towards mathematics education during the formative years of junior cycle post-primary.

1. There should be some emphasis on "traditional" mathematics, but the syllabus should also include logical puzzles which would be solved by discovering the underlying logical pattern.

2. There should be a certain amount of drawing to scale and construction of solids. Geometry is important from the viewpoint of graphical literacy which is the cornerstone of many professions in the field of engineering and architecture. In this context, there is a case for the introduction of a basic technical drawing programme as an adjunct to mathematics.

3. There should be an elementary introduction to matrices based on shopping lists and on the prices of normal household commodities. The examples should include addition and multiplication of matrices.

4. There should be more emphasis upon applied problems, and less emphasis upon theorems. This approach should make the subject more interesting and stimulating for young pupils.

5. The course should include library assignments on the history of mathematics with a particular emphasis on the role which mathematics has played in the development of science.

6. Topics which would relate to everyday experiences could include translating situations into mathematical sentences, identifying problems with too little or too much information, conjunction of sentences, translating to conjunctions, solving conjunction of equations, lever or torque problems, motion problems and problems connected with dynamic situations.

7. It is important to introduce the young mathematics student to computing.

8. Mathematics cannot be adequately taught in isolation from other subjects. Mathematics should be related to science, applied science, business

subjects, and to all other aspects of the work of the school which relate in any way to numeracy.

9. The use of a standard textbook and workbook for mathematics should be considered by teachers and the Department of Education. It is essential that some guidance be given to teachers on the pedagogical approach in addition to guidance on syllabus content.

10. The use of audio-visual aids, including film and video, should be encouraged. This will help to relate the subject, mathematics, to the world outside the classroom.

11. Mathematics should cover at least three important areas in which the student will be involved after school:

    - personal and social
    - vocational and work-related, and
    - leisure.

12. In relation to employment, the course should include the use of mathematics in areas such as:

    - bank accounts
    - wage and salary calculations
    - invoices, discounts and VAT
    - income tax
    - services bills, such as electricity
    - interest rates
    - profit and loss
    - the keeping of all types of statistical records

13. In relation to society, the course should cover such topics as:

    - higher purchase and loans
    - energy utilisation in the home
    - insurance and life assurance
    - social welfare benefits

- expenses in relation to home ownership
- everyday household outgoings
- the expenses of owning and running a car
- all other aspects relating to living in a modern industrial society

14. The course should cover the whole range of basic competency areas such as the ability to add, subtract, multiply and divide, and also the use of decimals, graphs, simple formulae, basic statistics and a knowledge of shape, area, volume and other related matters. The basic competency areas should also be related primarily to the needs of the pupil in the three areas: personal & social, vocational and leisure.

15. Some emphasis should be placed upon concepts such as neatness and layout. The presentation of information is often marred by inadequate layout or by the lack of neatness, and the effective communication of data is thereby lost. The concepts of neatness and layout should be emphasised within the mathematics syllabus from the earliest possible stage.

Those were the observations of the Confederation of Irish Industry about the junior cycle syllabus in May 1983. They are relevant not only to junior cycle but also to the teaching of mathematics at any higher level.

Applications oriented Mathematics

The Confederation of Irish Industry while recognising the need for a *balanced curriculum*, and while recognising the need to prepare young people for entry to higher education, must necessarily place some emphasis on the educational preparation of the majority of post-primary pupils who immediately enter the workplace directly from the post-primary school. In this context, the Confederation of Irish Industry has for a number of years financially supported the **Applications Oriented Mathematics Project** which has been developed by the North Tipperary Vocational Education Committee in co-operation with Thomond College of Education in Limerick. Not only has the Confederation given financial assistance to this project but the Confederation has been represented from the initiation of the project on an Advisory Committee which was established by the North Tipperary Vocational Committee to promote

the development of this prototype mathematics course at senior cycle which is intended to meet the direct immediate needs of young people entering employment. This course is now recognised by the Department of Education and the validation process involves people from education and from industry. The Confederation of Irish Industry endorses the aim of the course which is to equip pupils who will directly thereafter enter employment with a sound educational experience which is mathematically significant and which is appropriate to their needs. The specific objectives of this course are worth mentioning:

- provide pupils with a systematic approach, viz., modelling which is comprehensive enough to fit every situation including work situations
- promote mastery of selected mathematical topics including concepts, techniques, know-how and applications
- promote computational facility and use of electronic calculators and associated skills
- build the pupils' confidence in their ability to understand mathematics and to use mathematics
- provide an appropriate industrial/commercial context for the pupils' use of mathematics through practical applications, case studies and industrial visits.

Calculators and Computers

The Confederation of Irish Industry believes that there is a need for some memorisation of basic results but wishes to stress that, in modern circumstances, there is a wider role for the electronic calculator in taking the tedium out of more involved numerical manipulations and this role extends even to the primary school level. The Confederation believes that the calculator can be used creatively to explore relationships between numbers and to experiment with numerical patterns and procedures. At a more advanced stage, the Confederation believes that there is not sufficient stress on the role of the computer in mathematics education integrated with related applied areas. A great number of schools now have computer facilities and many of these have

good graphics capabilities. These are ideal for illustrating mathematical notions and results in the form of graphs, charts and other visual displays and are also useful for the implementation of excellent teaching and assessment programmes. The role of the computer even from the every earliest stages of education is vital as computers are now becoming so cheap and so powerful that they are a part of the total home and societal environment of many children.

Mathematics as a communications tool

The two subjects which are essential for any school leaver who enters business and industry are the language which is used in the workplace and the subject, mathematics. These are the tools with which people in industry communicate — those tools are required in order to learn, to understand, to evaluate, to plan, to record and to measure. In this context, it must be stressed that mathematics is a "language" and its great virtue is that, when properly applied, the communication in terms of mathematics is concise, unambiguous, and readily understood internationally. Mathematical symbols in common usage and mathematical symbols in the highest reaches of science are as readily understood in Paris, Washington and Tokyo as they are in Dublin and London. A message in terms of mathematical symbols can frequently be delivered much more concisely and precisely than a similar message given in terms of words.

Mathematics for the employee

Mathematics in terms of wage and salary calculations and in terms of wage negotiations are important to every person in employment. The new entrant to business and industry will find that the modern payslip contains so many items that it sometimes resembles more of a scientific computer printout and this can lead to misunderstanding and to grievances if the content of the payslip is outside of the mathematical experience of the young person. In order to competently analyse a payslip the young person requires a knowledge of basic arithmetic, a familiarity with percentages, cumulative totals, overtime multipliers, bonus calculations, net and gross figures, and other numerical concepts. The conclusion is that tuition in the intricacies of PAYE, PRSI and wage calculations should not be confined to business subjects alone but should be included in the general mathematics syllabus at junior cycle level.

Mathematics for the young worker

Young people who leave the post-primary school may well start production work in batch or process operations and all the stages of the young person's work will be measured in mathematical terms. This means that times will be recorded, weights and volumes will be recorded, there will be records of units produced, percentage unproductive waiting time, bonus ratings and other quantified information. In addition, the young worker would probably obtain instructions from the supervisor which are sometimes expressed in mathematical terms — degrees, weights, speeds, times, volumes and percentages. If the young worker is unable to correctly interpret these instructions, not only will production suffer but there may be safety risks. This latter point means that the young worker must not only be trained to understand the written instructions in the work schedule but must also be motivated to actually read and to act upon those instructions.

Promotion within Industry

Promotion for the young worker within industry from the shopfloor level to supervisory and first line management posts invariably requires that the young person should undertake some element of clerical work. This work includes recording daily/shift outputs, requisitioning materials from stores and recording other information in relation to work of operatives. The young person who is weak at mathematics may well find that his or her promotional prospects are limited on this account. One of the best ways in which to help a pupil who is still at school appreciate applied mathematics in an industrial sense is to involve pupils in group projects within the school. These projects can be part of subjects such as home economics, woodwork, metalwork and building construction. There are many examples of this type of group project run on a "mini company" basis in the post-primary schools.

EC Developments

If Irish industry is to continue to expand then it must continue to modernise and to introduce improved production techniques. There will be a growing emphasis on R & D and upon applied research. Research and development is one of the important factors in the integration of the EC Internal Market.

Special emphasis is being placed on areas such as biotechnology, information technology, mariculture and high technology areas of engineering.

The largest single EC Programme in the area of research and development is ESPRIT (European Strategic Programme for Research & Development in Information Technology) which will be worth more than IR£1 billion in its second phase, 1988 – 1992, and new applications programme will cover the information technology aspects of medicine, transport and education. Ireland is well placed to share in ESPRIT.

The most recent annual report of a second EC Research & Development Programme, SPRINT (Strategic Programme for Innovation & Technology Transfer) noted that the Irish Robotics Project is progressing smoothly. There is another programme called RACE (Advanced Telecommunications) which has recently added 40 additional projects in its second phase.

A wide range of other programmes were adopted by the Research Ministers of the EC at their meeting on 20th June, 1989, and these include areas such as preventative medicine and agri-research.

The Commission has put forward a 7.7bn ECU budget for the Third Research Framework Programme which covers the period to 1994. The French want Ministers to agree to this ambitious plan by the end of the current year. The proposed budget is likely to be challenged by some Member States. Unanimity is needed before the plan can be adopted. Resources will focus on six specific programmes whose proposed budget (in million ECUs) is as follows:

		ECUs(m)
1.	Information and communications technologies	3,000
2.	Industrial and materials technologies	1,200
3.	Environment	700
4.	Life sciences and technologies	1,000
5.	Energy	1,100
6.	Human capital and mobility	700

Existing and potential Irish beneficiaries should become acquainted with the significant new orientation of the EC's research strategy.

The ECLAIR research programme which relates to agriculture has a budget of 80 million ECUs for the five years 1989 to 1993. The EC Commission is promoting six lines of action designed to develop an EC policy for space research. The EC Commission recently announced details of new research and development programmes in the field of marine science and technology.

Relevant areas of research and development being promoted by the EC Commission include:

- scientific research
- technological development
- diffusion of research results
- strategic economic analysis
- databases
- technical standards
- Higher Education

Higher education has an extremely important role to play in order to ensure that Ireland can participate to the full in the EC programmes. On a wider basis, it is obvious that an increasing number of production and administrative staff will be required to master the use of "microchip" projects which will depend upon digital and numerical information for their operation. The Confederation of Irish Industry is acutely aware that investment in education and in training in Ireland is needed in order to enable Irish industry to offset the disadvantages of being an island nation on the periphery of Europe with a low per capita income.

The Confederation is recommending to the Government in a Pre-Budget Submission 1990 that public expenditure on education should at least be maintained at current levels in real terms. The Confederation is recommending that any funds which would otherwise be saved because of the anticipated phased drop in primary school enrolements by up to 20% should be redeployed to increase the Irish participation rate in third level education to 50% of the relevant age cohort compared with about 25% at present. This increase should focus particularly on qualifications in greatest demand for economic development purposes, such as engineering, computer science and business studies.

The Confederation in ranking the priorities for investment in Ireland with aid from the EC Structural Funds placed special emphasis on investment in higher education which should include post-graduate work and research and development. The Confederation emphasised links between industry and higher education not only in terms of the direct educational input but also in areas such as industrial parks, innovation centres, research parks and science

parks. The Confederation placed a focus not only on technological education but also on business education and on all faculties in the higher education institutions on the grounds that all faculties contribute to intellectual development.

Three Major Points

There are three major points which need to be emphasised from a business viewpoint in relation to mathematics.

1. It is essential to inculcate a positive attitude towards mathematics in all school leavers and, in order to do this, it is essential that parents, teachers and employers must have a positive attitude towards mathematics. Points which need to be emphasised in this context include:

   - basic mathematics is essential as a skill which, just like riding a bicycle, can only be developed through individual effort and through practice.
   - Mathematics is not just a subject for the "boys"; if girls are to avail of the increased range of careers now opening up to them, it is essential that they be able to compete on an equal footing with boys in the area of mathematics. This implies that there must be a new approach particularly to the availability of higher level mathematics at senior cycle in "traditional" single sex girls schools.
   - Mathematics is just as important in the private life of the individual as it is in the workplace. Calculations in relation to the monthly mortgage payment or in relation to the economics of using a motor car are acquiring a new importance in the life of the individual.

2. The presentation of mathematics in the schools should, in so far as possible, be related to the applied subjects which are studied by students. Problems based upon examples from home economics, woodwork, metalwork, chemistry, physics, business organisation, accountancy and other applied subjects should be introduced as an integral part into the mathematics syllabus. An increased emphasis should be placed upon graphical presentation of information in recognition of the fact that there is a growing emphasis upon chart and diagram format of presentation of information. This is seen in the print and television news media where there is a growing use of flow charts, histograms, and pie-charts which are intended to enable the reader or the audience to rapidly assimilate statistical data. Mathematical applications are also seen in the growing sophistication of computer games and toys.

3. Teachers should be encouraged to maintain and to strengthen links with business and industry. This type of contact is important not only for the guidance counsellor but should extend for the benefit of all teachers, including teachers of mathematics. In this context, the Confederation of Irish Industry established an education trust in December 1983, to financially assist research and development work undertaken by teachers' subject associations. Financial assistance has, to-date, been given for projects in chemistry, physics, junior science, biology, mathematics, geography, history, computer studies, art and design, business subjects and modern languages.

The business community fully recognises the dynamic role which education plays in the development of a modern industrial economy and recognises the centrality of mathematics for this purpose within the education process. The important role which mathematics plays in the curriculum needs to be continuously reinforced by keeping syllabuses up-to-date, by researching "state of the art" practices and procedures and by the implementation of a planned programme of in-service training for teachers with appropriate mechanisms to link the teaching of mathematics to its application in business and in the wider general community. Progress does not stand still in the workplace or in economic development; it cannot be allowed to stand still in the world of the mathematics and in the classroom of the mathematics teacher and of the mathematics student.

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