University Mathematics: The Cradle of Thought for effective policy-making

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NO STUDENT SHOULD LEAVE UNIVERSITY without partaking of the legacy of knowledge that the renowned Greek mathematician and philosopher Plato left us. "Let no man ignorant of geometry enter here;" so read the inscription over the door of Plato's academy. The Greeks raised the Egyptian and Babylonian mathematical tools to the level of abstraction. To them we owe the power and poetry that is the meaning of University Mathematics today. Do we still harbour the utmost respect that the Greeks paid to Mathematics? Do we still have their conviction that only through the spirit of inquiry and strict logic could one understand a person's place in an orderly universe?

Mathematics is as old as humanity. In every time and culture there have been people with a compelling desire to understand and discover more of the form of the natural world around them. Mathematics, originally meant to encompass all knowledge, has nowadays a relatively restricted scope: quantitative and spatial concepts, order and form, logic and structure, algebra and geometry together with a wide range of interdisciplinary fields. Little do we realize that the many gadgets we would not do without today, such as the dynamo, the motor and the signal transmitter or receiver, are run by a system of equations; that Mathematics has shaped the luxuries and necessities we have today; that it is the key to the new cures and the cutting edge innovations and technologies of tomorrow.

Mathematics is unique among the Sciences and Humanities. It is not a set of opinions. It is not even a set of truths but a beacon of light that enables truths to be found. Mathematics is versatile. It can be invented by composing new axioms or discovered by developing existing theories further. Mathematics may be considered as a minute fraction of the art of creation. It is an intellectual instrument that has shaped our world throughout man's historical journey. Generating Mathematics gives us a taste of God's joy of creation. Great mathematicians, like Copernicus, Kepler and Newton, have taken the world by storm. They have changed the course of history because their creations have moulded their perception of life into a more realistic one.

Mathematicians create a hypothetical world, mostly based on real-life experience and enjoy the thrill of unlocking the mysteries, signs and wonder of their own design. They learn how to learn and are not bonded to a particular skill that easily becomes outdated. Mathematics is both an art and a science. The tension between the two attitudes reflects the conflicts that arise among its several branches as well as within the wide range of disciplines that owe their *raison d'être* to it.

Mathematics is a way of thinking. The mathematician does not fear confrontation since no argument can undermine correct results which are based on an accepted system of axioms. Mathematics is a way of structuring our thoughts and arguments and is alien to illogical, often confusing regulations and interpretations of the law. The clarity of logical theory often conflicts with reality. This explains the friction that ensues when, at scientific meetings, mathematicians sit at the same round table as other scholars who start savouring power-wielding political positions and enjoying experiments with hazy strategy.

The western world is seeking pragmatic solutions, tending to use Mathematics as a tool, vying to render the various disciplines economically viable. Such trends can spell doom to a seat of learning where creativity should be the ultimate goal. Researchers need liberty and time to produce effective results and this is particularly necessary for mathematicians. In his *Metaphysics*, the Greek philosopher Aristotle says that the mathematical sciences originated in Egypt because there "the priestly class was allowed leisure to preserve knowledge." No wonder mathematicians strive to seek contentment in a world of their own creation, especially when the ever increasing administrative obligations infringe upon the time that would otherwise be dedicated to deep thought.

The word *university* means a unity of knowledge. Students and academics meet to seek after knowledge, truth, discovery and creativity for their own sake, striving to achieve personal competence, leadership and above all integrity. Though an ancient and venerable institution, established in 1592, our university is in constant renewal. Long experience has established the good quality of the degrees it awards. The extent by which they are transferable to the most prestigious universities worldwide, as a basis for higher degrees, is the measure of our high standard. To increase the nation's respect and retain its standing as one of the best universities worthy of its name, it is important to continually appraise its status and the direction in which it is heading.

Teaching is a two way communication system. The primary aim is the benefit to students but it also elicits in teachers an intense sense of altruism and an urge to facilitate the path leading to their students' academic success. The teaching staff in the Department of Mathematics are committed to produce a future generation of mathematicians capable of designing higher levels of theory and to empower their students with the ability to think critically, analyse logically and reason scientifically. Emphasis is laid on establishing attitudes that enable the students to increase their self confidence in the subject to such an extent that they will be able to conceive new theories or develop existing ones further without fear.

The university campus is the cradle in which our students are encouraged to lead, to set their goals, to set policies and take decisions that affect society. Mathematics, as a creative discipline, is more than apt to facilitate the students' growth to maturity. A mathematician is like a curious child who has the intuitive and imaginative powers to break away from age-long rigid traditions. S/he has a revolutionary force of spirit that motivates one to set new standards. These leaps in the dark require tenacity and courage. Seeing ahead of the times is often dangerous as history teaches us. Those who were naïve enough to publish radical concepts during their lifetime and insist on their truth, were at best ridiculed even by their peers or dismissed from their universities.

When studying mathematics, students bathe in a luxury of precision where they can focus on a set of non-conflicting rules at a time. This contrasts with what often happens in the real world of physics, chemistry, biology and medicine, where external factors often mask the principal result. Above all, mathematicians acquire the habit of observing all details and sifting from the whole mass of data the bare essentials sufficient to reach their aim. They are trained to solve problems effectively and efficiently. The country benefits from utilizing such intellectual power in all strata of policy making.

For our university to enjoy the high ranking it deserves among world universities, it is imperative that the academic staff in our geographically isolated location have the possibility to participate in new

developments occurring overseas and to export their new creations for possible adoption as a basis for research. The benefit to students from such interaction among academics has become more apparent in recent years. The Department of Mathematics boasts of joint research with academics from universities and research institutions in Serbia and Montenegro, England, Scotland, Ireland, Italy, Bulgaria, the United States, Canada, Russia, Japan, the Czech Republic and Slovakia. Whereas we are developing theories in combinatorics, graph theory, eigenvector techniques, quantum logic, differential equations and physical Mathematics for the sake of their beauty, we are also looking into the possibility of contributing to the interfaces with other disciplines. Of particular interest to us, is the study of error codes, data structures and molecular energy.

In what way is our university unique? What is the Mathematics Department contributing which is of relevance to society today? We are certain that the graduate scientists that we mould according to our expertise are capable of delivering results. Through the projects that the Mathematics Department sets its students towards the end of the course, we realize that the Mathematics graduates will manage to deliver what the labour market expects of them. The students are given three weeks in which to self-learn a mathematical software language and are asked to produce a program to solve a proposed idea effectively. Even though the performance of our students during classes and final exams is proof enough of their ability, what they deliver in these projects leaves no doubt as to their worth as designers, thinkers and above all executers, reliable and responsible in a work environment. They can meet any challenge where creativity and design are required.

The strategy of the Mathematics Department is to focus on all stakeholders without allowing any to destroy its traditional values. This demands corrective feedback for continual evaluation by reacting to emerging scenarios. We need mathematicians who are able to overcome the fragmentation that confuses and to unify theories; people who are able to have a clear global view of most relevant results. It is as if these people have the possibility to climb up to the roof of a multi-storey building from where they can relate sites well below them and determine the potential for interaction among these sites.

Students are encouraged to question established theorems, to produce new proofs to existing results and to create new theories. To this end, the Mathematics Department hosts a series of workshops held bi-annually. Initially intended as a pedagogical exercise, the *Collection* workshops and seminars have developed into a more meaningful exercise. Results have surpassed even the best expectations. The exercise has evolved into a tool that identifies the golden particles of the talent and aptitude in Mathematics among our young. Students and staff meet to exchange new ideas, pose new problems and arouse an exciting yearning for more exposure to Mathematics. Such interaction does wonders in building the self-confidence that students so desperately need to persevere in the challenging subjects that may initially prove difficult to understand. It motivates them to prove themselves among their peers and mentors. For some students, the outcome is an eloquent example of how a possibly lost cause is turned into a win. These seminars have proved to be the breeding ground for students who fell in love with mathematical creativity and decided to continue with postgraduate studies. Participants of the *Collection* workshops strongly acknowledge the role of such activities in fostering personal development and encouraging independent thinking and initiative. In his book, *To be a Pilgrim*, Basle Hume writes "The love of God dawns slowly." The same can be said of the intense interaction with Mathematics.

These bi-annual seminars require a great deal of effort to organise. We seek to search for a balance in the wide scope of Mathematics and in the new interests of the Mathematics population at the university and all over the island, a balance of ideas and even of gender among participants. The preparatory session in which the organisers discuss the validity of the theories that the speakers have created and secretly nurse with pride and an element of trepidation, needs to be handled with care. While encouraging the students' interests, the organisers must ensure that the result of the whole exercise will be to increase, not only the participants' understanding of the subject but also the latter's standing in the local mathematical community. The organisation of the actual event also requires attention to ensure that all possible support is given in terms of equipment and physical space. Attracting the right kind of audience is crucial for the participants to feel appreciated. It is vital that audience and speakers are made to feel important. The hardest work, however, starts after the event when the articles need to be collected and photos developed. The editorial team meets regularly to publish the proceedings. This is an opportunity for the students to learn mathematical typesetting software and the format a paper should take to be accepted in a respected mathematical journal.

Editing original work is a demanding job, especially since new theories are prone to error. The greatest lesson the participants learn from these experiences is that as my friend, Ted Hurley of the National University of Ireland, states in a postscript to his e-mails, "He who never made a mistake, never made a discovery." It is very encouraging for the teaching staff to learn that in their classes they have students who can discuss and question established results. It often comes as a surprise to tutors that they triggered off the interest of the students in the areas that they came across first at university and that they motivated the students to adopt Mathematics as a creative hobby.

The *Mathematical Society* born within the Mathematics Department and continually sustained by it, seeks to attract the interests of the Maltese at large. National issues related to Mathematics are discussed and the society seeks to emphasize the presence of Mathematics in most of our pastimes, home activities, commercial works, art and industry.

Besides Mathematics, our students study another subject, usually Physics, Statistics or Computer Science which complements the former. Will a person who has gone through the mill of listening, making one's own, understanding and overstepping the threshold from accepting and copying to taking the initiative to make innovative endeavours, leave society, the place of work or the family unaffected? Equipped with an understanding of a wide scope of knowledge, our graduates can provide the nation with the brain power for innovation and sustainability. It is up to the nation to ensure that it avails itself of this preparation and turns it into a bundle of opportunities by avoiding under-employment of our graduate power.

Albert Einstein, who is acknowledged as the genius of the last century, gave the best tribute one can give to Mathematics: "God is a mathematician; subtle are the ways of the Lord." It normally takes two to three generations to realize applications from theory. Whereas the jump to a new theory is done by one individual, it is invariably the result of several smaller steps that require a slow understanding. Sir Isaac Newton called the many people who prepare the spade work, "giants on whose shoulders we stand to be able to discover more of the infinite ahead of us." This more than justifies the time spent by mathematicians in creating theories that initially seem to be a figment of the imagination, futile and unrealistic.

True researchers see the need for a balance between the lure for immediate returns, achieved by recycling current knowledge and the painstaking creation of new ideas and search for new discoveries. The former may appear to pay in the short term but excluding the latter will have us stagnate in a rut. Poor and to be pitied is a university that becomes richer at the expense of suppressing creativity which is not immediately marketable. Researchers demand faith from industry and society in general, in their ability to create attitudes conducive to growth. The country receives much from the university and in turn it is bound to give the university the possibility to exercise its freedom in its service to truth and innovation.

It is important that we elicit trust from society. The images of the scientist and his/her prime supporter, the mathematician, that are projected to our students and the general public need to be that of facilitators who improve the quality of life, of healers committed to prolong life and improve the environment, rather than of enigmas, of manufacturers of explosives or of polluters.

With the opening of our doors to Europe, Malta is at a crucial juncture. It can stand on the pillars that the university can provide or go into a lull by under-utilizing the product we produce. Whether the country suffers a brain drain or a brain gain depends on the respect that the nation shows towards its graduates. European academics and researchers are following with interest the efforts by the European Commission to fund and promote scientific research. In spite of the seemingly wide range of thematic areas in the current EU research programmes, most scientists cannot identify their fundamental research with these funded programs. Forty-five Nobel prize-winners teamed up to outline these concerns to European Commissioner for Research, Philippe Busquin. Professor Tim Hunt emphasizes that the journey of creation and discovery along which researchers tread is initially unknown and cannot be formally laid down in a contract as required by the current EU funding mechanisms.[1] Sir James Black confirms, "If we have any thought for our future, we must invest some of our wealth in the long term creation of new knowledge."

References:

[1] *European Research Council*, Cordis Focus, European Commission * Innovation, 20th Oct, 2003.

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