Keynote Speaker

Universities & Reasearch Through the Ages

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"I have never done anything 'useful'. No discovery of mine has made, or is likely to make, directly or indirectly, for good or ill, the least difference to the amenity of the world."

G H Hardy (1940)
unknowing contributor to
21st c. digital cryptosystem

"Good morning everyone, and thank you for joining us today. I have been asked to deliver a keynote presentation today. But I will not take up too much of your time, for I know that there are many other more interesting things awaiting you after this.

Considering that we will be spending the whole day indoors, I thought it might be a good idea if I were to take you on a tour first. It will be a historical tour, but with a glimpse of the future. We will be looking at how the university as a universal model of higher education, and its research, emerged and have developed over time. And how these have contributed to our civilisation. I hope it will give you something to ponder while listening to the presentations during the rest of the day, and hopefully after this conference as well.

Let us begin with a history of the university. We will travel back in time to Europe, to around the year 1000 AD. At the time, there were various establishments already in existence which offered refinement in education. These were principally cathedrals, monasteries, courts and various forms of apprenticeship. All these establishments shared a commitment to a curriculum--one that has over time developed into what is known today as the system of liberal arts. Hundreds of subjects were taught then, each essentially committed to one of the seven key arts, namely the trivium made up of grammar, dialectic and rhetoric; and the quadrivium comprising arithmetic, geometry, astronomy and music. And in those places in Europe where Christianity met Islam, Western education was heavily influenced by Eastern education and traditions. In fact, around that time, the flow of knowledge was almost one way, from the East to the West. This education landscape did not spring from nowhere. Its root dated back even further than the time of Plato's and Aristotle's Academies. It is fair to say that no one really knows the true origin of teaching, training and passing on knowledge.

But what we are interested in today is **how the university model of further education emerged.**

It is unclear how the first university came about, but against this backdrop of a rich, cross-cultural educational scene, there seemed to emerge coherent bodies of scholars who were committed to **discovering new truths**. This eventually led to establishment of what is recognised today as the university model of further education. The first university, the University of Bologna was

officially established in 1088. Soon afterwards came the (old) University of Paris in 1150, Oxford in 1167, Palencia in 1208 (now defunct), Cambridge in 1209, Salamanca in 1218, and Montpellier in 1220. Within a few generations the idea of the university spread throughout Europe. And despite the differences in the focus of teaching, and in the social and academic settings of these early universities, they have one thing in common: the quest for new truths was always central to their emergence. And, as we know, over a thousand years on, the university model of higher education is still going strong, spreading throughout the world and taking a big part in shaping it.

So, **Why is the university model of education so popular and durable?**

A key factor that has made it so successful was that the development of new ideas and understandings by scholars under the auspices of universities--equivalent to what we call 'research' today--was seen by states and authorities throughout the ages as central to cultural and intellectual enrichment, prestige, and state competitiveness in trade and politics. This was especially true from the early 15th century onwards, when a new idea called humanism emerged which believed that men could make sense of the world around them using reason, experience and shared human values, and that they could live good lives without religious or superstitious beliefs. This idea exacerbated the thirst for knowledge, for an understanding of the world; and has propelled deep rational inquiries across a range of subjects. It is these deep rational enquiries that paved the way for research that we know today, research which is an investigation based on 'scientific' rational thinking, rather than on faith, and which takes nothing for granted. And over the course of a thousand years, there have been many, many deep enquiries based on this principle.

At this point, some of you may ask, **What tangible fruit have these deep enquiries--or research--ever borne?**

A short answer is plenty, and it would take days, even months, to list them all. But what I will show you today is something different. I will show you that for one's work to have a great impact, it needn't have identifiable practical purposes or even be considered an astounding success at the time it is carried out.

Now, why should anyone ever carry out research which has no apparent use? Why should anyone ever carry out research whose outcome cannot be guaranteed? After all, if you are a student, you are always asked to identify before you embark on any piece of research its potential applications, beneficiaries, expected outcome, and so on.

Apparently, those great minds of the past whose works have made so much impact today, pursued their enquiries simply for the sake of satisfying their own intellectual curiosity. They did it because the problems were new, because they were a venture down a path unknown. And the legacies of what they did live on today.

Take, for example, Swiss scholar Leonhard Euler. In 1736, while at the Prussian Academy, he tackled a problem known as the Seven Bridges of Königsberg. The city of Königsberg, Prussia was set on the Pregel River, and included two large islands which were connected to each other and the mainland by seven bridges. The problem was to decide whether it was possible for one to follow a path that crossed each bridge just once and return to the starting point without retracing one's steps. Euler considered this puzzle and realised that algebra, traditional geometry or the art of counting was unable to solve the problem. So, he developed a new concept of geometry of position, according to which all traditional measurements like lengths

and angles were irrelevant, and the only thing that mattered was how things were connected. Based on this new concept, he then figured out that to cross all the bridges without retracing one's steps it was necessary for each of the land mass which the bridges connected, except the one at the beginning and the end of the route, to have an even number of lines coming in and out.

Now, what is the point of all this? This is merely a pastime puzzle, isn't it?

Who would have thought that this solution to what one might call a pastime puzzle would today be driving the greatest network that humankind has ever known: the Internet. The principle of the internet is that we want one computer to connect to another, say a to website server, as quickly as possible, and the principle developed by Euler almost 300 years ago to solve the Seven Bridges puzzle is embedded in all computers that make up the Internet today, to enable them to connect to one another as quickly as possible.

Our next example is Henri Poincare. His story took place in 1885, when King Oscar II of Sweden offered a prize for anyone who could establish theoretically whether the solar system would forever continue turning like clockwork, or whether at some point in the future, the Earth might spiral out of the solar system, a problem which had eluded mathematicians since Newton's time. Poincare, while at the University of Paris, submitted a solution for three bodies orbiting one another under their own gravity, not unlike the system of the Sun, the Earth and the Moon. Despite the fact that he did not solve the problem completely, the contribution of his work was considered significant enough to secure the prize. However, our story is not really about how he addressed the problem and won the prize. Rather, we are interested in what went on after that.

It was every scholar's nightmare. Poincare had just been awarded the prize and his paper had been typeset ready for publication. Then, one of the editors raised a question about a step in his proof. Poincare rechecked it and realised it was indeed a mistake. He telegraphed the head of the prize committee trying to limit the damage by retracting the paper; publishing an erroneous paper in the honour of the King would cause a furore. Alas, it was too late: the paper had been distributed. Attempts were then made over the next few weeks to retrieve the distributed copies quietly, and Poincare was asked to pay for the printing of the first erroneous edition, which costed him 3,500 crowns, 1,000 crowns more than the prize he had originally won. In trying to sort out the mistake, he realised that it was not OK to approximate the problem in the way he did, that a small change in the initial conditions would only result in a small change in the outcome. In turned out that for certain systems/phenomena, even one simply defined, a small change in the starting conditions could lead to vastly different outcomes. This concept later led to one of the most important concepts of the last century: the theory of chaos--the idea that a butterfly flapping its wings in one corner of the earth could cause a storm in another corner. And today, understanding chaos is at the heart of weather forecasting. To get around these butterfly effects, forecasters today have to run as many computer simulations as possible, each with slightly different starting points, to work out the most likely outcome.

Our last example takes us closer to the present day, to the 20th century. It involves G H Hardy of Cambridge who died just after the Second World War. The area of study with which Hardy was most obsessed was the prime numbers, the numbers which have only two distinct natural number divisors: 1 and itself. It is a fact that every whole number is either a prime or can be produced

by multiplying together two or more primes (e.g. 6 = 3*2). Therefore, prime numbers can be regarded as the building block of mathematics, and this is what got Hardy interested in them. Hardy asked two questions which nobody knew answers to. Is there a formula for identifying the prime numbers that make up a given whole number? And how are primes distributed in the universe of numbers? Hardy dedicated his life to tackling these questions, and although he made some progress in many respects, until his death he was unable to solve them. To the present day his questions remain unanswered. But the fact that they remain unanswered has proved immensely useful to us. Every time you log on to your email account or buying something on the Internet, you send your private information such as your name, address and credit card number flying about the cyber world. To protect this information, a system has been developed to encrypt it. What this system does is use a 200-digit number to perform a calculation to scramble your data. To crack your data (without the passcode), a criminal needs to find the two prime numbers which when multiplied together produce this 200-digit number. Since there is no formula for identifying these prime numbers, the only way to crack your data is to break each 200-digit number into two primes and see. That would take a life time. So, but for G H Hardy's 'failure' in being unable to understand the prime, we would not have a safe cryptosystem that we know today.

These three stories are just examples of works which were considered a waste of time or a failure at the time they were carried out, but which were pursued simply because they were new, they were fundamental, they were adventurous intellectually; and which later on changed the world.

This tradition of original, adventurous, fundamental research, in fact, lives on to the present day in what is generally regarded as top universities in the world. Central to the perpetuation of this tradition is the integration between research and teaching. In the science, at least, it is no coincidence that we see in these top universities the largest numbers of graduates who went on to become Nobel Laureates (Figure 1). Also recently, many Asian countries have realised that, not only to raise GDP and increase their living standard, but also to enhance international respect and attract international cultural and intellectual interactions, they need to raise their game in research. China, for example, has increased in recent years its research output. In terms of the number of scientific papers (used here since they are more easily traced than publications in arts and humanities). In 1996, the US published 292,513 papers--more than 10 times China's 25,474. But by 2008, the US total had increased just slightly to 316,317 while China's had surged more than sevenfold to 184,080. It is expected that Chinese output will take over US output by as early as 2013.

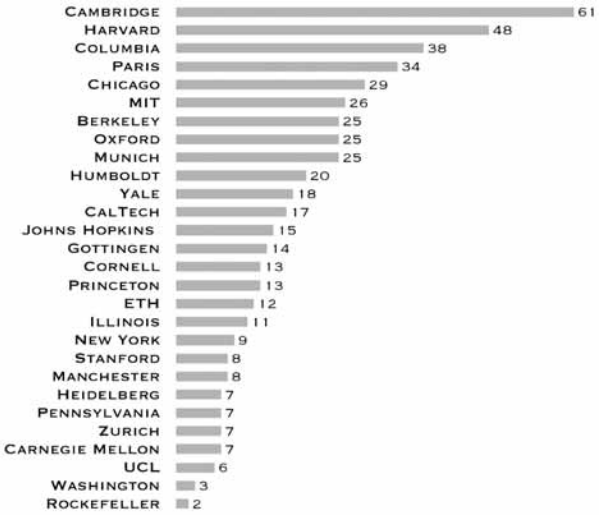

Figure 1. Number of graduates who went on to become Nobel Laureates in different university.

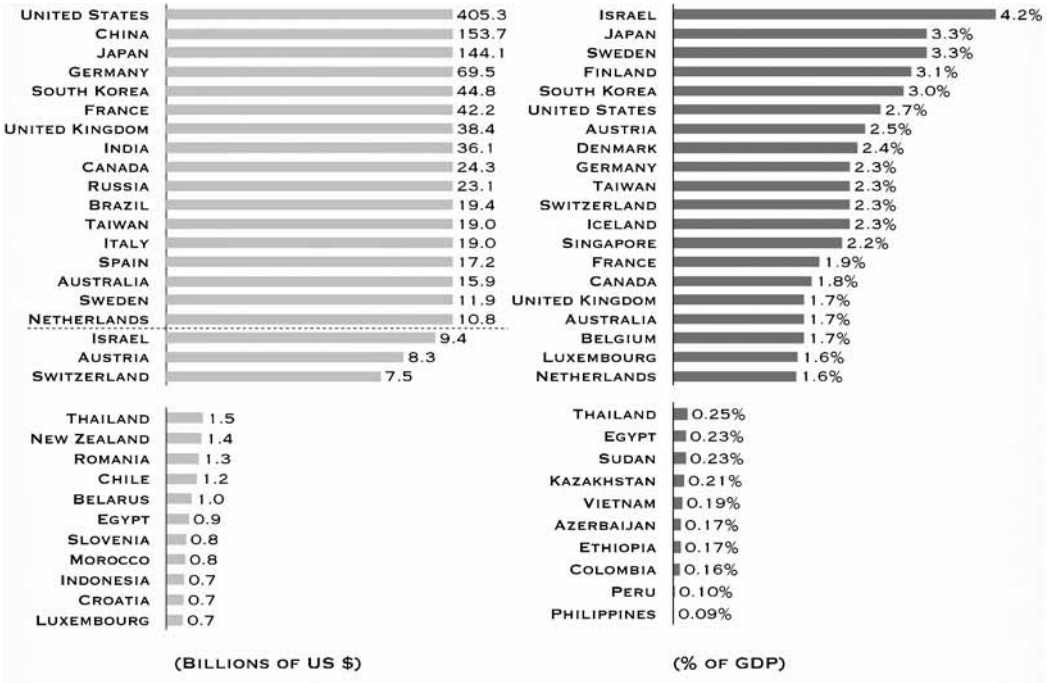

Figure 2. Annual spending on research in different countries.

All these should come at no surprise, for if we take into account the fact that China's spending on research has grown by 20% per year since 1999, now reaching over $150 billion. In fact, it can be seen that all the leading economies and those aspired to become ones like Korea, Taiwan, India and Brazil have continuously spent large amounts of money on research. And while it is true that size does not always equate to quality, this does make for a larger pool from which more high-quality research can be drawn. Unfortunately, for some reasons, Thailand's investment in research is puny, even in terms of percentage of GDP.

High-quality research is key to developing a country intellectually, culturally, economically and politically. BERAC, with its aim of encouraging research activities and academic discourse, is a step in the right direction to improve the intellectual scene of Thailand. Last year, 72 papers were presented. This year, the number has increased by 10% to 78, which is to be congratulated.

The papers this year are divided into five areas: building technology, design theory, management and property development. The focussesare diverse, with different methodologies employed, which is only fitting for today's world with increasingly complex problems.

Hopefully, what we will hear and see during the rest of the day will encourage the production of good research in years to come. And for those of you who are students, I hope you will carry on making original enquiries even after you have completed your degrees. **Remember, if it's original and adventurous, it's worth doing; no one really knows what impact your research will make in the future.**