

STRATEGIES AND PROGRAMMES FOR PRODUCING SCIENTISTS AND TECHNOLOGISTS

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ABSTRACT

The field of Science and Technology has long proven its contributions to the global economy. BioBusiness which is based on biological or life sciences alone estimates 50% or more of the GDP of some countries, accounts for more than 25% global GDP (US\$9 trillion), and employs of no less than 40% of the global workforce today.

Brunei Darussalam has long recognised the importance of Science and Technology. Brunei education system plays a key role in building human resource needs in Science and Technology. It produces Scientists and Technologists among others in oil and gas producing sector, Ministry of Industry and Primary Resources (Agriculture, Fishery and Forestry), health and education. Science has been introduced in lower secondary schools, and continues to be offered as National Diploma, Higher National Diploma and, both under- and postgraduate degree programmes. The degree programmes in Science and Technology offered by the Higher Institutions usually depend on the needs of the country for example, Universiti Brunei Darussalam introduced Bachelor in Science Education in the 1987 because Brunei Darussalam did not have enough science teachers at that time.

The question to be addressed now is whether our current strategies and programmes in producing scientists and technologists will sustain in the next five years? Are we going to stay in the same mould? A definite change in direction is vital. First and foremost is for Brunei Darussalam to increase its funding in Science and Technology. The funding will be used to develop human resource needs in Science and Technology, build infrastructure for Science and Technology, introduce more high-tech programmes in

higher institutions and support Research and Development. Secondly is to have a coordinating agency, responsible for all policy matters pertaining to Science and Technology development in Brunei Darussalam. The question which should be addressed by this agency is on how Brunei Darussalam's Science and Technology should be heading? Thirdly is to promote awareness in Science and Technology through scientific exhibitions, workshops, seminars, career talks and conferences. One of the aims would be to nurture Science and Technology to our young generation. The role of Non-Government Organisations, on the other hand, would be to complement activities already done by the Government agencies.

1.0 INTRODUCTION

Science and Technology can be described in three phases: (1) The Age of Chemistry in the 19th Century; (2) The Age of Physics in the 20th Century which was fueled largely by exciting developments in the physical and engineering sciences and; (3) The Age of Biology in the 21st Century with new insights and developments in the life sciences and biotechnology. The mapping of human genome in 2001 has been described as the post-genomic era. Innovations in the life sciences and biotechnology through development of new tools for biomedical diagnosis or treatment, innovations in terms of new and improved crops, new biofuels as substitutes for fossil fuel and new biomaterials to replace plastics or textiles. Such developments will have impact on Gross Domestic Product (GDP) of countries venturing in these areas. Science and Technology has long proven to generate economic growth. BioBusiness which is based on biological or life sciences alone estimates 50% or more of the GDP of some countries, accounts for more than 25% global GDP (US\$9 trillion), and employs of no less than 40% of the global workforce today (Shahi, 2004). Biobusiness spectrum includes the biomedical, agri-ventinary, food-related, environmental and industrial. Scientific and technological advancement parallel with social evolution, starting with agricultural society to industrial society and to knowledge-based society. The latter deals with discovery, invention and innovation.

This paper will attempt to discuss the development, current status and future directions of science and technology and, in producing expertise in this area in Brunei Darussalam.

2.0 SCIENCE AND TECHNOLOGY IN BRUNEI DARUSSALAM

Science in Brunei Darussalam was introduced as formal education in schools almost 90 years ago. Professional and technical workers have increased by 3,125 from 34,365 in 2001 to 37,490 in 2005 (8th NDP 2001-2005).

2.1 Science in the early days

Education played a very important role in bringing science to schools in Brunei Darussalam. Herein, the development of science education is described in three phases (Zohrah, 1996): (1) before 1950; (2) from 1950-1972 and; (3) after 1972.

2.1.1 Science education before 1950

Science was not introduced into the school curriculum immediately even though formal education began in Brunei Darussalam in 1912 (Chevalier, 1912). The introduction of health science (basic training in personal cleanliness) into schools in 1918 may be explained by the awareness of the authority at that time of infection diseases such as tuberculosis (Cator, 1918). Gardening started in 1922 (Allen, 1922) followed by the study of arithmetic in 1936 (Black, 1936) and in 1949, the first book on "Nature Study in the Tropics" was introduced in schools (Pretty, 1949). During the second world war, all schools were closed temporarily from 1944-45 (Padmore, 1955-57).

2.1.2 Science education from 1950-1972

An important milestone in education was achieved in 1951 when the Department of Education was established (Barcroft, 1951). The new department was to function towards a modern education system (Education in Brunei Darussalam, 1987). The following year saw the establishment of the first government English medium school in Brunei Darussalam (Brunei Annual Report, 1952). Gardening was renamed as agriculture and it was taught in all classes starting from Primary 3 students and upwards. The British trade school became Technical Trade School in 1952 and technical subjects such as diesel mechanics were taught in this school (British Annual Report, 1952).

Junior secondary education was introduced in 1954, and it was divided into five streams: (1) commercial; (2) pre-technical; (3) pre-agricultural science; (4) advanced studies in

Malay and Chinese and; (5) Cambridge external examination, university degrees and diplomas (Brunei Annual Report, 1954). In 1955, Sultan Omar Ali Saifuddien College (abbreviated as S.O.A.S.C) was opened. The phase 2 development of the college included building new facilities such as laboratories for teaching pure science subjects such as Biology, Chemistry and Physics (Brunei Annual Report, 1955). This project was completed in 1957 (Brunei Annual Report, 1957). Before 1957, pure sciences were not taught in Brunei secondary schools for two possible reasons: (1) lack of facilities for teaching science practicals and (2) lack of qualified science teachers. Therefore, contract education officers were employed for teaching science and mathematics (Padmore, 1955-57). Anticipating the need for more qualified teachers, the Education Department established the first teachers' training center (Brunei Annual Report, 1956). The center was later renamed the Sultan Hassanal Bolkiah Institute of Education. Today, the institute is a part of Universiti Brunei Darussalam.

In 1968, two engineering schools were built and both schools started to accept students in 1971 (Brunei Annual Reports: 1966 and 1971). The two engineering schools were Maktab Teknik Sultan Saiful Rijal Technical and Maktab Kejuruteraan Jefri Bolkiah. A year later, Scottish Integrated Science syllabus was introduced in lower secondary schools (Brunei Annual Report, 1972).

2.1.3 Science education after 1972

The beginning of 70's saw marked improvement in science and technical education in Brunei Darussalam. Nuffield science in modern physics, chemistry and biology was introduced to secondary five students in 1974. Science subjects were later offered to lower secondary students. Further development in education took place in the mid 1980's. The first of these was the establishment of Universiti Brunei Darussalam in 1985. In 1987, the university through the Faculty of Science and Sultan Hassanal Bolkiah Institute of Education offered four-year degree programme in science education. The introduction of this programme is necessary as Brunei Darussalam at that time did not have enough science teachers. The Faculty of Science also offered twinning programmes in Computer Science (1990/91), Electrical and Electronic Engineering (1990/91) and Biotechnology (2003/2004). Other science programmes include MSc in Petroleum

Geoscience, B.Sc Biological Science (2002/2003), B.Sc.Applied Physics (2005/2006) and B.Sc. Chemistry (2005/2006). The Faculty of Science also offers MSc and PhD by research. Institut Teknologi Brunei was established in 1986. It offers higher national diploma and degree programmes. Technical education has expanded further through establishment of vocational schools. Maktab Jururawat PAP Rahidah Sa'adatul Bolkihah was formed in 1986 and is the only institution which offers nursing education.

2.2 National Development Plan (NDP)

The importance of science and technology has always been emphasized in the National Development Plan (NDP) of Brunei Darussalam.

Biotechnology was incorporated in the Sixth NDP (1990-1995), tissue culture was first started in the Brunei Agricultural Research Centre. In the Seventh NDP (1996-2000), the Brunei Government recognized the importance of information communication technology and engineering as vital to nation building. Promotion and enhancement of learned society, from consumer to inventor, that aim to bringing out talents (discoverer, inventor, innovator and creator) were also emphasized. The seventh NDP saw the promotion of science and technology through interactive science exhibition and participation of secondary school students in the APEC Youth Science Festival. The Government of Brunei Darussalam invested over US\$2 million in the Seventh NDP to promote awareness in S & T, develop human resources for S & T, build infrastructure for development and expansion of S & T and foster collaboration with overseas organizations.

Under the Eighth NDP (2001-2005), the Government invested 0.08% of the total NDP budget in the development of Science and Technology which covers the following areas:

- Human Resource Development in S&T;
- Develop R&D infrastructure;
- Promote S&T Awareness;
- Enhance International Linkages.

It was clearly stated that Brunei Darussalam had to rapidly develop its human resource in science and technology with aim to produce a society which is creative, inventive, innovative, capable and efficient in utilizing and applying high technology. A separate budget (over US\$200 millions, which is 2.7% of the total Eighth NDP budget) for ICT. The Eighth NDP also states that networking between local and overseas research institutes should be encouraged and so is networking between local research institutes and private sectors. The effort to strengthen infrastructure for science and technology activities will be further enhanced as the Government of Brunei Darussalam is keen to develop high technology industry. High technology includes biotechnology and microelectronics. The global market for biotechnology in 2001 is US\$40 billion

2.3 The Role of National Committee on Science and Technology

In realising the importance of science and technology, National Committee on Science and Technology was formed in 1994. The Chair was the Minister of Development and R & D Unit under the Ministry is responsible in coordinating science activities locally, regionally (ASEAN-COST) and internationally (APEC). The Unit also supports R & D by funding research projects in Universiti Brunei Darussalam and Institut Teknologi Brunei. The overall objective of the committee is to ensure that Science and Technology (S & T) can effectively contribute to economy, environment, social and culture. The term of reference of the committee is as follows:

- Regulating the development of S & T in Brunei Darussalam;
- Formulating policy towards expansion of S & T in Brunei Darussalam;
- Developing physical infrastructure for expansion of S & T in Brunei Darussalam.

2.4 The Development of R & D in Science and Technology

Research and development is vital in technological advancement. Investment in R & D mostly comes from government fund with a Gross Expenditure on R & D (GERD) of 0.02% of GDP which is well below the ASEAN GERD average of 0.4% of GDP (Tan and Olofinjana, 2005). At present research works in Brunei Darussalam are being carried out by the following establishments:

- Universiti Brunei Darussalam;

- Kuala Belalong Field Studies Centre, UBD;
- Institut Teknologi Brunei Darussalam;
- Brunei Agricultural Research Centre;
- Medical Laboratories;
- Department of Scientific Services Laboratories, Ministry of Health;
- Public Works Department Construction Materials Research Testing Laboratory.

The Brunei Darussalam Research Council was established on 1 October 1987, it is a body responsible for formulating and determining national policies on research and guidelines for promoting, facilitating, coordinating and regulating the conduct of research activities in Brunei Darussalam (Zohrah & Hazri, 2004).

Universiti Brunei Darussalam (UBD) and Brunei Agricultural Research Centre in Kilanas are the two leading Government's institutions involved in scientific research activities. Research is UBD's second mission. It states "As a nation's only university, UBD will promote and undertake research, particularly applied research, in areas it has a comparative advantage and in accordance with national needs." UBD is also the secretariat to the Brunei Darussalam Research Council. In UBD, scientific research is often carried out either by individual academic staff or a small group of academic staff. The research grant usually comes from UBD's Research and Consultancy Committee. The maximum amount for UBD's research grant is over US\$10,000. The grant may also come from local organizations for examples, Sultan Haji Hassanal Bolkiah's Foundation and Government Departments, and overseas sponsors for examples, ASEAN Regional Centre for Biodiversity Research (ARCBC), RAMSAR and Third World Network of Scientific Organizations (TWNSO). UBD's academic staff is also encouraged to collaborate with other foreign universities in areas of mutual interests. The facilities for scientific research can be limiting at UBD, and collaboration with foreign institutions will enable UBD researcher to conduct research in the partner's laboratory. There are also workshops and conferences in the Sciences offered by ASEAN-COST and other organizations. ASEAN-COST activities are usually funded by ASEAN and the host institution.

The strategies of Faculty of Science (FOS) in research can be summarised as follows:

- Identify and prioritise areas of research of importance to Brunei Darussalam, and encourage research in these areas by channeling funds into such research;
- Take initiatives to secure funding for applied research through government and private sector organizations;
- Encourage collaborative research between staff of the FOS and other departments within the university and with staff of overseas institutions;
- Improve junior local staff research output through strengthening the counterpart system with senior academic staff;
- Actively seek support from outside organizations for the provision of research facilities, including equipment, computers and personnel;
- Encourage academic staff to publish their research findings in local, regional and international journals.

The advantage of Brunei Darussalam is its rich genetic resources. Most scientific research in Biology Department is geared towards biodiversity of flora and fauna.

There is also inter-faculty project involving Faculty of Science and Faculty of Business, Economics and Policy Studies on conservation management of Pulau Selirong. The project spans for 2 years and is sponsored by RAMSAR in Japan.

The Kuala Belalong Field Studies Centre (KBFSC) is a centre of research for lowland forest. It is located in the Batu Apoi Forest Reserve, Temburong. Over the years, it has attracted UBD's students, school students, research scientists (both local and foreign), government officials and private organizations. Research fellowships for KBFSC and Faculty of Science are also available and it is usually taken by foreign scientists. The research topics are usually related to the country's needs.

The scientific findings by UBD staff and research fellows has been published in local, regional, international journals and books. UBD is a publisher of one scientific journal: Bruneiana Scientia, a merger of two former journals- Science Bulletin and Bruneiana: Anthology of Science Articles. The Office of Postgraduate Studies, Research and

Development was established in 2000 and placed under the purview of the Deputy Vice-Chancellor and the Dean. The Office will undoubtedly help to promote scientific research in the university and country.

Brunei Agricultural Research Centre (BARC) is a research and development division under the Department of Agriculture, Ministry of Industry and Primary Resources. The center was formerly known as Kilanas Agricultural Research Centre. In 1993, Kilanas Agricultural Research Centre was named as Brunei Agricultural Research Centre.

When BARC first started, its function was more as a production station supplying planting materials and livestock breeds to farmers. Towards the 1970s, the station was reorganized into functional research disciplines with the establishment of Entomology, Pathology, Soil Science, Agronomy and Livestock Units. The Centre continued to be productive where new agronomic practices were added to crop production and knowledge on soils and water, pest management and disease control were developed to benefit farmers engaged on the production of agricultural commodities. Between 1989 and 1995, much progress and development has been achieved by BARC, among which includes the pursuit of initial work on medicinal plants, completion of mushroom laboratory, trials on protected cultivation, tissue culture, natural product, food technology and post harvest laboratories. Two volumes of Medicinal Plants were published in 1992 and 1995.

Research activities of BARC concentrates on crops namely rice, fruits, vegetables and ornamentals. The development of cost effective technology for farmers to increase production and encompassed various disciplines including crop agronomy, crop protection, plant nutrition and post-harvest technology are included in its research activities. In 2002, Department of Agriculture established Agrotechnology Division within BARC, Biotechnology Unit is under Agrotechnology. The Unit is responsible in tissue culture project and at present, it carries out tissue culture of mushrooms including production of mushroom spawns, tissue culture of banana and ornamentals (orchids, ferns, pitcher plants, Durian and anthurium). The scientific research laid out for Agriculture Department in the Eight NDP of Brunei Darussalam will include:

- Integrated pest management;

- Screening local flora having medicinal properties and commercialization of the products;
- Qualitative breeding of plants.

BARC also continues to be involved with ASEAN-COST sub-committee on Biotechnology and, Food Science and Technology. BARC has Durian project under ASEAN Regional Centre of Biodiversity Research (ARCBC).

2.5 Science and Technology Linkages

Brunei Darussalam has fostered linkages with research and development institutes and laboratories from ASEAN and APEC member countries. ASEAN-COST (Committee on Science and Technology) plays an important role in developing human resources in science and technology through training and technology transfer.

There are eight sub-committees under ASEAN-COST: Biotechnology, Food Science and Technology, Meteorology and Geophysics, Microelectronics and Information and Communication Technology, Materials Science, Conventional Energy, Marine Science and Science Infrastructure and Resource Development. Brunei Darussalam continues to collaborate and communicate with other international organizations such as APEC-ISTWG, and COMSTEC on issues pertaining to Science and Technology.

2.6 The Role of Non-Government Organisations

The role of Non-Government Organisations, on the other hand, would be to complement activities already done by the Government agencies. Non-government organizations (NGOs) such as Brunei Association for Science Education (BASE), Persatuan Biologi Brunei Darussalam, Institute of Chemistry and Physics Society play an important role in promoting Science and Technology among students and professionals. These societies also work closely with Science, Technology and Environmental Partnership (STEP) under the Ministry of Education which was formed in 1997. Recently, the opening of Oil and Gas Discovery Centre at Brunei Shell helps to raise awareness in Science and Technology.

3.0 FUTURE DIRECTIONS

Are we having enough scientists and technologists? The answer is no.

Our Gas and Oil Industry still require expertise in among others, engineering and Geoscience. We are not near in producing enough experts in this industry.

Are we going to produce scientists and technologists using the same strategies and programmes? Will we able to supply human resource needs in Science and Technology? R & D is important to drive Science and Technology in the country. As mentioned earlier, the GERD of Brunei Darussalam is only 0.02% compared with Singapore's 2.2%. Brunei Darussalam has long recognized the need to diversify its economy of oil and gas (Brunei Darussalam, 1999) and necessary steps are taken to look into other alternative.

Brunei Darussalam is lagging behind in respect of S & T development. We contribute fund for regional cooperation (for example, ASEAN-COST) and yet we do not fully benefit from it because we do not have expertise in the areas. High-tech training is usually beyond us. Most ASEAN countries have launched their life science and biotechnology programmes. Singapore for example started getting serious about life science and biotechnology in the mid-1980s. Now Singapore is a world-class manufacturing hub for pharmaceuticals and has established leading centers of life science excellence including Genomic Institute of Singapore and Institute for Molecular and Cell Biology. The centerpiece of Singapore's life science drive is Biopolis which is responsible in bringing together key government agencies, publicly funded research institutes and R & D laboratories of pharmaceutical and biotechnology companies. Indonesia has set up "BioIsland" near Batam and intend to attract international collaborations in bioprospecting, fermentation technology, bioremediation, biodiversity protection and medical technology. Malaysia launched "BioValley Malaysia" in 2002. It consists of three research institutes: (1) Genomics and proteomics; (2) agricultural biotechnology and (3) nutraceutical/ pharmaceutical technologies.

3.1 Funding in Science and Technology

Sufficient funding in Science and Technology is crucial in getting Brunei Darussalam into the next stage. Our R & D capability have not been exploited to the fullest. The 0.02%

GERD of GDP will not be enough to sustain R & D for development of Science and Technology. Funding will be used to:

- Develop human resource needs in S & T;
- Build infrastructure (physical and scientific) in S & T;
- Introduce more high-tech programmes in higher institutions;
- Support R & D.

3.2 Coordinating Agency

Unlike other countries, Brunei Darussalam does not have an agency to oversee Science and Technology activities. Its role is not only coordinating science and technology activities but responsible for all policy matters pertaining to Science and Technology development in Brunei Darussalam. The question which should be addressed by this agency is on how Brunei Darussalam's Science and Technology should be heading? At present, each Ministry has its own agenda as far as Science and Technology are concerned. It is not cost effective because effort may be duplicated through lack of coordination among government agencies.

3.3 Promoting Science and Technology

Promoting awareness in Science and Technology through scientific exhibitions, workshops, seminars, career talks and conferences. Universiti Brunei Darussalam through the Faculty of Science has organized UBD Science and Technology Week for two consecutive years now. One of the aims would be to nurture Science and Technology to our young generation. Brunei Darussalam also promotes scientists among school students by introducing Princess Rashidah Young Nature Scientist Award (PRYNESA) through Forestry Department. Brunei Scientists can also compete for ASEAN Young Scientist Award and ASEAN Outstanding Scientist Award. Institut Teknologi Brunei Darussalam has recently introduced Cipta Award, the objective is to encourage invention among students, scientists and public.

4.0 CONCLUSION

In conclusion, initiatives to develop science and technology programmes in Brunei Darussalam usually comes from ministries namely the Ministry of Education, Ministry of

Communications, Ministry of Industries and Primary Resources. The programmes are supported by funds from the National Development Plans. Human resource The future plans for Brunei Darussalam in producing scientists and technologist must include substantial funding in Science and Technology, establishment of coordination agency in Science and Technology and promotion awareness in Science and Technology to our young generation because they are our future leaders.

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