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National Science Foundation - Taking the country forward through Science and Technology

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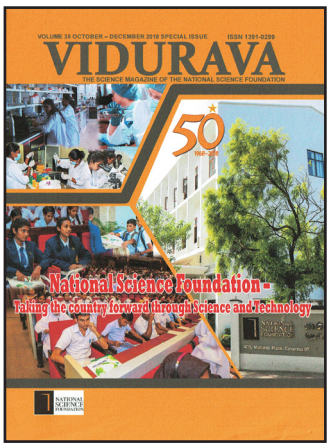

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Editorial

National Science Foundation - Taking the Country Forward Through Science and Technology

As National Science Foundation (NSF) stands on the threshold of its 50th anniversary celebration on the 4th of October, this special issue of 'VIDURAVA' focuses not only on the past, but also on the future. Volume 35 for the October-December 2018 period turns back the pages of time to the beginnings of NSF, the predecessors of which were Natural Resources Energy and Science Authority (NARESA) and National Science Council (NSC) and dwells on the rich and unparalleled history of this unique institution and its role of "taking the country forward through science and technology".

With the basis for major breakthroughs in science and technology in the world being a questioning mind fuelled by curiosity, 'VIDURAVA' paves the way for men, women and children to think beyond the routine and mundane.

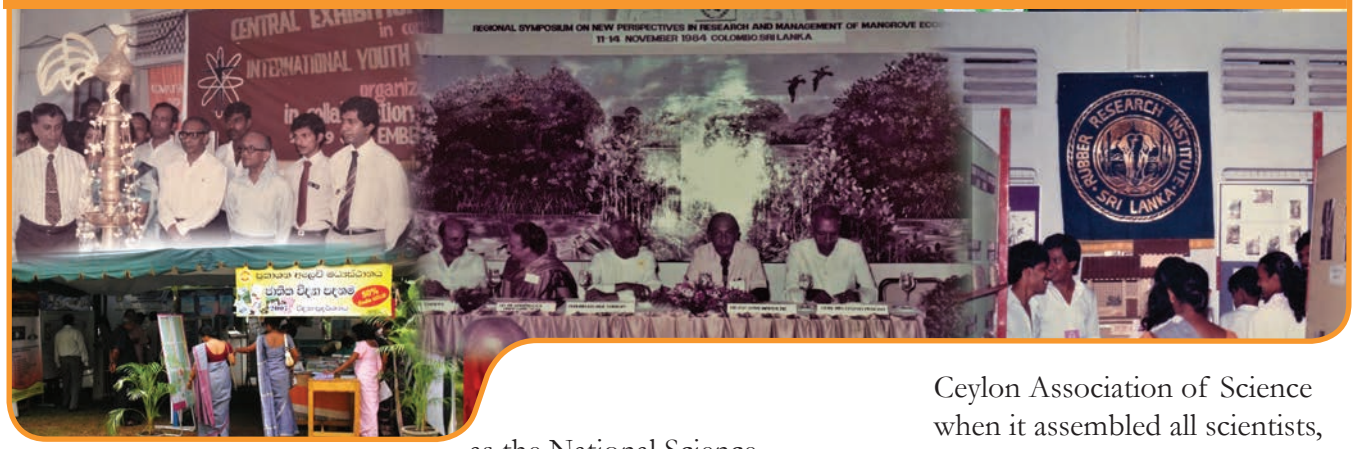
The goal of the Magazine being to take science to the people, over the years that is what 'VIDURAVA', published as a quarterly in all three languages of Sinhala, Tamil and English, has been doing.

In keeping with its mandate, this issue of 'VIDURAVA' too has wide and varied topics – from 'Technological Skills to Win the World' to 'The Secret of Becoming a Successful Science Teacher' which may coax children to think in this direction, for what better role models are there than teachers.

The other topics are 'The Need to Make Science Popular and Take to the People'; 'Scientific Research in a Developing Nation'; 'Science for Evidence Based National Policies' and much more. The science teacher's way of popularizing science through dramas, viridu, songs, acting and stories is very interesting and could be used as a model, adapted to suit different areas of the country, to catch them young and enthral school children about the wonders of science.

National Science Foundation – An Institution with a Unique History

M. Asoka T. De Silva



National Science Council (NSC), the predecessor of the National Science Foundation (NSF) was not offered on a platter to the scientific community of Sri Lanka. It had to go through a 20 year phase of agonizing agitation, during which period fortunes fluctuated between hope and despair.

The history of the National Science Foundation (NSF) was exceptionally rich and unparallel. It is the pioneer organization assigned with the task of planning and policy development of science, which can be traced back to 1941. This historical record can be conceptually considered to comprise two distinct phases. The first phase - the forerunner was from January 1941 to May 27, 1968 when the National Science Council was created. The second phase commenced from May 28, 1968 when it progressed sequentially through several structural and functional transformations over a period of 50 years to be finally remoulded as the National Science Foundation.

The initial events began to unfold in January 1941 with the formation of the Ceylonese-dominated Chemical Society of Ceylon. This professional body was formed on a proposal made by Mr N. G. Baptist, an outstanding scientist of that era. The British Governor of Ceylon, Sir Andrew Caldecott had given formal recognition to the appointment of a "Scientific Advisory Committee" to the colonial government based on the recommendation of the Chemical Society of Ceylon.

The objective of the Scientific Advisory Committee was to advice the colonial government on matters pertaining to industrial development and research.

In December 1942, on a suggestion made by Mr. D. H. Wadia, a former President of the Indian Science Congress, the Chemical Society of Ceylon spearheaded the formation of the Ceylon Association of Science when it assembled all scientists, engineers, medical scientists, and social scientists in the country under one banner.

The Ceylon Association of Science was re-constituted in July, 1944 as the Ceylon Association for the Advancement Science (CAAS). Historically, this was also the year that a draft for a national constitution was prepared for Ceylon, with the help of Ivor Jennings (later Sir Ivor), the then Vice Chancellor of the University of Ceylon. The Chemical Society of Ceylon thus brought together a diverse and heterogeneous group of scientists, engineers, medical scientists and social scientists under one umbrella organization.

In 1948 a memorandum to the Prime Minister, Hon. D. S. Senanayake, and the Cabinet of Ministers, CAAS pleaded for a 'Council for Scientific Research', which forced the Government to seek the assistance of the World Bank, which in turn recommended the establishment of the Ceylon Institute of

Scientific and Industrial Research (CISIR.) This was in order to resolve the so-called "main grievances" of the scientists.

Thus, when a new government came into power in 1956, CAAS continued its agitation and re-submitted its request for a Council of Scientific Research. Also as an interim measure, CAAS constituted within its organization a committee called the "General Research Committee", which had as its main function to foster scientific and industrial research. They met Prime Minister Hon. S. W. R. D. Bandaranaike and the then Minister of Lands who agreed to consider their request, which prompted CAAS to prepare a draft Act. Interest in this subject however, began to fade when the term of office of the government drew to a close.

In 1961, the Ceylon Association for the Advancement of Science adopted a resolution requesting the new regime to appoint a "Science Commission."

A Cabinet Paper was prepared for the establishment of a 'National Research Council' (NRC). In 1963, although there was dissatisfaction over the Cabinet proposal further discussions leading to the drafting of a fresh Cabinet Paper proposed the appointment of a 5-member 'Science Commission' as a preliminary step to the setting up of the NRC.

At this stage the government sought the assistance of UNESCO to set up these organizations. The final proposals were approved by the Cabinet and its formal announcement was made by the then Prime Minister, Hon. Sirimavo Bandaranaike, in December 1963, at the Annual Sessions of the CAAS.

However, in 1965, negotiations recommenced with the new government that came to power. In December 1965, the new Prime Minister Hon Dudley Seneneyake, in his inaugural address at the Annual Sessions of CAAS, declared that he intends to set up a new Ministry for Research and Technical Education.

The Ministry of Planning and Economic Affairs at this stage stepped in to resolve the main areas of conflict in the draft Act, by submitting fresh proposals to CAAS. Many of these new proposals were received favorably by CAAS.

While these discussions were taking place, CAAS itself went through a transformation, when it was incorporated by an Act of Parliament in April 1966.

Birth and Early History of the National Science Council

It has to be noted that the Government of the day proposed the setting up of a Ministry for Scientific Research which was implemented by setting up of a Ministry of Scientific Research and Housing in January 1968. This move was followed up later by the establishment of the National Science Council by Act No: 9 of 1968, as an alternative to the previously suggested National Research Council. The NSC was thus established as a statutory body under a Ministry, and unfortunately fell far short of the expectations of the scientific community, which hoped for an autonomous scientific organization with usual administrative and financial bottle necks removed.

The inaugural ceremony for the establishment of the National Science Council took place on May 28, 1968, with Hon. Prime Minister, Mr Dudley Senanayake as the Chief Guest and in the presence of Ministers of the

Sir Nicholas Attygalle - The first Chairman of NSC

relevant Ministries. It was presided by Sir Nicholas Attygalle, the first Chairman of the Council.

It is remarkable that apart from issues concerning scientific research, all the guest speakers drew the attention of the new Council to the need to formulate a science policy for the country. Mr D.P.R. Gunawardena, Minister of Industries and Fisheries, in his Address, drew the attention to the scientific and technological strides made by India after independence and he went on to elaborate the 10 - point "Scientific Policy Resolution" placed before the Indian Parliament, ten years earlier on March 4, 1958, by the then Prime Minister of India.

Obviously inspired by these sentiments, the newly appointed Council at its very first meeting held on 29th May, 1968, established a sub-committee to prepare a draft statement on Science Policy, which was to be the basis for the first seminar to be organized by the National Science Council.

The Act of Incorporation of the National Science Council specified the functions of the Council as well as, a) the constitution of the Council, b) the process of electing the Chairman, and c) the procedure for the selection and appointment of the Chief Executive Officer (Secretary General).

It is on record that at the first meeting of the Council, a request by the Chairman for volunteers for the post of Secretary General had a negative response. Subsequently on a formal proposal, Mr. B.P.J. Alles was elected as Acting Secretary General but held office on a part time basis until September 1969 when Dr C.R. Panabokke took over office as the first full time Chief Executive of NSC.

Dr C.R.Panabokka - The first full time Chief Executive of NSC

The first Council appointed by the Minister of Scientific Research and Housing comprised the following members:

1. Sir Nicholas Attygalle – Chairman
2. Dr G. Ponnamperuma
3. Dr A.N.S. Kulasinghe
4. Mr. L.D.J. Fernando
5. Dr P.P.D.L. Siriwardena
6. Prof. S.W. Bibile
7. Dr Charles St. George
8. Dr S. Gnanalingam
9. Prof. E.O.E. Pereira
10. Mr B.P.J. Alles
11. Dr J.W.L. Peries
12. Dr V. Appapillai
13. Dr R.P. Jayewardene
14. Prof. B.A. Abeywickrema
15. Prof. H. Crusz
16. Mr D.B. Rampala
17. Prof. A.S. Dissanayake
18. Dr E.F.L. Abeyratne
19. Mr W.D.V. Mahatantile (Permanent Secretary Ministry of Scientific Research and Housing)
20. Dr Gamini Corea (Permanent Secretary – Ministry of Planning and Economic Affairs)
21. Mr B. Mahadeva (Permanent Secretary – Ministry of Agriculture and Food).

Sir Nicholas Attygalle held office for 18 months and was succeeded by Dr A.N.S. Kulasinghe.

In the absence of a professional staff in the Secretariat, the Council largely operated through ad hoc Committees, the first of which was the sub-committee of the Council to draft a Science Policy statement for the country. In April 1969, in response to an application received from Prof. F.S.C.P. Kalpage for a research grant, the Council set-up another committee called the Research Grants Committee to evaluate and make recommendations.

And following the discussion with the new Minister of Industries and Scientific Affairs, a memorandum was prepared and submitted to the Cabinet for the reorganization of the Council with one difference, i.e. the Research Board being renamed as the Scholarship Board.

List of Chairpersons

Sir Nicholas Attygalle	April 1968 – January 1970
Dr. A.N.S. Kulasinghe	February 1970 – February 1972
Prof. Osmund W. Jayaratne	March 1972 – February 1977
Ptof. E.O.E Pereira	October 1977 – May 1982
Dr. R.P. Jayewardene	June 1982 – April 1992
Prof. Priyani E. Soysa	May 1992 – 1998
Prof K. Dahanayake	1998 – August 2001
Prof. Eric Karunanayake	15 August 2001 – January 2002
Prof. Ranjan Ramasamy	February 2002 – April 2004
Prof. Sirimali Fernando	August 2004 – June 2013
Prof. W. Sumathipala	July 2013 – February 2015
Mr. Iqbal Mohamed	February 2015 – June 2015
Prof. Sirimali Fernando	June 2015 - Onwards

1972, following the reconstitution of the Council, the Cabinet of Ministers made the following observations:

The Cabinet agreed that the Council had not been able to carry out its major functions effectively, primarily due to the fact that the Council as a whole had no direct links with the Ministries under which the major scientific activities in the country were carried out. The National Science Council had therefore tended to work in isolation.

To achieve greater co-ordination among the various sectors of research activity presently carried out in various departments, research institutes and Universities, it was suggested that the Ministries having related functions should be grouped in such a manner as to make possible the implementation of research and development activities pertinent to that group of Ministries.

It was proposed that a Standing Research Committee should be set up for each group of Ministries. The Chairman of such a Committee appointed in consultation with the particular Minister concerned will be appointed as a member of the National Science Council by the Minister of Industries and Scientific Affairs.

These members would thereby be in a position to transmit to the National Science Council, the scope and range of research activities in the different Ministries. This would assist the National Science Council to formulate an overall policy for scientific research.

In consideration of these observations of the Cabinet, the Council proposed Standing Research Committees for which Chairmen were appointed in consultation with the relevant Ministries.

In August 1975, the National State Assembly sanctioned its enactment as the National Science Council of Sri Lanka Law No:36

List of Cheif Executive Officers

Mr B.J.P. Alles	Secretary General April 1968 – August 1969
Dr C.R. Panabokke	Secretary General (Secondment)
Dr G.C.N. Jayasuriya	Secretary General March 1971 – September 1978
Dr R.P. Jayewardene	Secretary General November 1978 – May 1982
Dr R.P. Jayewardene	Director General June 1982 – April 1992
Prof. Priyani E. Soysa	Director General May 1992 – 1998
Mr M. Watson	Director 1999 – December 2004
Dr M.C.N. Jayasuriya	Director 2005 – March 2009
Dr S.A.K. Abayawardana	Director May 2009 – December 2011
Mrs H.A.U. Amarasinghe	Director General February 2012 - 2013
Mrs Sunethra Perera	Acting Director General 2014
Mrs H.A.U. Amarasinghe	Director General Up to 14 May 2015
Dr Thamara F. Dias	Director General (Covering) June 2015 - Sept 2017
Dr Jayantha Waththevidanage	Acting Director General Oct 2017 – Dec 2017
Prof. Ananda Jayawardane	Director General Jan 2018 onwards

of 1975. The Law however was to become operative more than five years after the Council had initiated steps to rectify the defects in the first Act of Incorporation of the NSC.

The new Act widened the scope of work of the Council with emphasis on planning and policy development for science and technology. In particular the Act empowered the Council to study and report on:-

(a) The effective utilization of the available scientific and technical personnel in Sri Lanka;
(b) The future scientific and technical manpower requirements for the effective implementation of the science policy of Sri Lanka; and
(c) The steps to be taken to provide adequate training facilities to meet future scientific and technical manpower requirements.

The composition of the Council according to the new Act consisted of seven appointed members and six ex officio members, making in all a 13-member Council. The ex officio members represented ministry officials from relevant Ministries, who would facilitate in "achieving greater co-ordination among the various sectors of research activity carried out in various departments, research institutes and universities."

The Chairman of the new Council was appointed by the Minister from among the appointed category of members. The Act also permitted the Minister, on the recommendation of the Council, to appoint Working Committees deemed necessary to assist the Council in the performance of its duties.

A further amendment was introduced to the NSC Act No.36 of 1975 in November 1979, whereby the clause dealing with the appointment of Council members was repealed and a new clause provide for the appointment of eight members by the Minister. The numbers of ex officio members were limited to three.

The final outcome of these reforms was a reasonably good institutional setup, with operational flexibility as well as with meaningful provisions for coordination and co-operation in scientific and technological work. But due to the Government's

concern for appropriate action in the fields of natural resources, and energy and for further expansion and exploitation of the scientific skills of the country it was necessary to restructure to continue the new policy objectives of the Government.

The Crowning Glory of NSC – Commencement of the Research Grants Scheme

In 1970, National Science Council commenced the awarding of grants for scientific research. In the first year, the Council recommended 23 Grants to the new Ministry of Industries and Scientific Affairs for allocation of funds. Thus for the first time in Sri Lanka, funding became available for what may be referred to as curiosity-oriented basic research.

In 1975, major amendments were introduced to the NSC constitution. With these amendments provision was made for the appointment of statutory working committees in specific areas of interest. Consequent to these amendments, six statutory committees were appointed with Ministerial approval, which included the Statutory Working for Science Policy Research.

Between 1977 and 1978 the National Science Council's Statutory Committee on Science Policy Research formulated a policy framework on science and technology and by September 1978, a seven-point proposal generally described as the National Science and Technology Policy Statement was preprared and placed before the government for consideration. This Policy Statement was subsequently promulgated by the Executive Head J.R. Jayewardene in September 1978, at the Annual Sessions of SLAAS. He also realized the need to re-structure the National Science Council by empowering it with the additional task of overseeing the scientific and technological development of the environmental and energy sectors.

The scope of activities of the National Science Council thus was widened to include natural resources and energy. With these changes, in June 1982 the NSC Act was repealed and in its place the Natural Resources, Energy and Science Authority (NARESA) was created. Thereafter, its hierarchical position in the government's organizational structure was changed by placing it under the Presidential Secretariat. Significant changes that took place however was the disbanding of the Statutory Committee for Science Policy Research and the transfer of its functions to the Board of Management. In terms of planning and policy development in science and technology, this move was considered as an ill conceived and a retrograde step. Nevertheless, NARESA continued to carry out one of the main functions of the National Science Council that is, advising the government on specific issues relating to science and technology policy. Its main thrust however, was to enhance the research capability of young scientists, and thereby building a viable scientific community.

The success of NARESA's efforts to enhance research capability of young scientists was evident from the output of post graduates and publications. Between 1970 and 1984 this scheme of awarding Grants produced 70 qualified in MSc and six with PhD qualifications. And over 150 scientific publications out of a total of 261 received Grants.

Induction of the Science and Technology Development Act In 1989, with a change of government, NARESA was transferred from the President's office to the Ministry of Industries, Science and Technology, and subsequently it was placed within a new Non-Cabinet ranking Project Ministry for Science and Technology.

The government, assuming that there was a slackness in science based activities, appointed a 'Presidential Task Force on Science and Technology Development' (PTF) in1991 in order to review the situation.

It consisted of nine senior scientists representing different disciplines. The terms of reference of the Task Force included a review of the current status of science and technology in the country and

the formulation of strategies for the use of Science & Technology in industry, in agricultural modernization and in poverty alleviation. The report of the task force was submitted to the President in November 1991, in which a ten-point policy framework for the 1990s was recommended.

The Birth of the National Science Foundation

The provisions of the Science and Technology Development Act were generally rejected not only by the scientific community but also by the then Parliamentary Opposition. Nevertheless, despite vociferous opposition, the Government went ahead to get the Act passed in Parliament in April 1994. However, the Government sensibly refrained from implementing it due to their own realization that it was not a piece of popular legislation.

The new coalition government that came into power re-established a separate Cabinet level Ministry for Science and Technology. The new Minister sought advice of leading scientists and scientific organizations on the feasibility of implementing the Task Force recommendations.

However in April 1998, the succeeding Minister of Science and Technology took a decision to implement one of the main recommendations of the Task Force and implement the Act which necessitated major institutional reforms.

Through the provisions of this Act, some of the original functions of NARESA were delineated, and the role of formulating science policy was assigned to a new institution designated as the National Science and Technology Commission (NASTEC). While the task of undertaking Science & Technology policy research was allocated to the newly created National Science Foundation (NSF) it technically replaced NARESA. Therefore, National Science Foundation was established in 1998 under the Science and Technology Development Act No.11 of 1994.

It was also expected to carry out country-wide statistical surveys on the scientific resource potential of the country in order to generate viable statistics and indicators. This was to help effective monitoring and decision-making in respect of all aspects of science and technology development and for application of scientific considerations in national development planning.

In 1999, NSF was identified as the focal point for development of a Manpower Information System on S&T (MIS) under the ADB project on S&T Manpower Development. In 2000, NSF established the STMIS database under the above project. After seven years of expanding the facilities of the NSF library, in 1993, NSF Digital Library-the first of its kind in Sri Lanka offering on-line access to the full text of NSF journals, was launched.

In 2002, NSF was identified by the National Committee of UNESCO as the focal point of celebrating the World Science Day for Peace and Development. Thereafter, the celebration of this event in Sri Lanka continued to be organized by NSF. When the World Science Day School Programme was begun, it provided the opportunity for school children to play a major role in this celebration. It afforded popularization of science among the school community through various scientific activities that came under the World Science Day School Programme. The first World Science Day celebration in Sri Lanka with the school community a milestone in the NSF history was held at 'Navarangahala,' Royal College, Colombo on November 10, 2004. Thereafter, this programme up to the year 2016, was conducted annually, on a grand scale under different scientific themes.

The structure of the Scientific Division was changed in 2005 with six Divisions being established at NSF. These were Research Division (RD), Science Popularization Division (SPD), Technology Division (TD), International Liaison Division (ILD), and National Science Library and Resource Centre (NSLRC) established to carry out the mandated activities more precisely and efficiently in accordance with the Science and Technology Development Act

No.11 of 1994. Though the scope of the NSF of its inspection task was widened, it continued to prioritize the research and other relevant activities.

The introduction of the Equipment Grants Scheme in 2005 by NSF widened the support to local scientists. It helped them to purchase equipment essential for conducting their research activities which otherwise they cannot afford to purchase on their own. The introduction of Spare Parts Grants Scheme facilitated maintenance of equipment provided to researchers.

NSF initiated a multidisciplinary Coordinated Thematic Research Programme (CTRP) in 2005. This was done to reorient and drive the national research system to produce well defined outputs that would directly benefit the stake holders in the short term.
After the Tsunami on December 26, 2004, NSF decided to make people take informed decisions on natural disasters. Therefore, the NSF in 2005, through the Science Magazine on TV (Mihimadala) - Phase I and a series of short video programmes on natural disasters, created awareness amongst the general public on mitigating and minimizing the loss of life and damage to property. Other current scientific topics were also added to this series, but were produced as separate productions in Sinhala, Tamil and English. The first documentary on 'Tsunami' was telecast on Independent Television Network (ITN). The production of 13 science video programmes under Phase-I was completed in 2006. This video series won one National Award e-Swabhimani Special Merit Award awarded by ICTA and an international award - "Manthan Award South Asia 2011" from the Digital Empowerment Foundation, New Delhi in 2011. This was the very first International Award won for a programme organized by the NSF. Based on the success of Phase-I, another series of

National Science Foundation

Prof. Sirimali Fernando
Current Chairperson
National Science Foundation

15 short video programmes was produced and telecast on Rupavahini in 2018.

To create awareness among children on Tsunami, a children's story book on Tsunami titled 'Muhuda Kalu Wuna' (The Sea Darkens) written by Ms. Sumithra Rahubadda on the invitation of NSF was launched in 2005. This children's story book won a National Award for 'The Best Children's Story Book' category at the State Literary Award Festival 2005.

With the objective of creating a pool of science communicators in the country for bridging the gap between scientists and the general public, a three day Workshop on training of trainers on skills for science communication to the public was conducted in early 2005. This had the participation of two experienced science communicators from India who trained 30 scientists as trainers of science communication. This was followed by a series of such workshops in many places of the country.

By the Act No. 11 of 1994, NSF was mandated to develop natural resources in Sri Lanka. Therefore, the Foundation worked hard to protect natural resources in the country. Under the Man and Biosphere Programme of UNESCO, approval was obtained from the International Coordinating Council (ICC) in 2005 for the development Bundala National Park as a Biosphere Reserve. Earlier, in 2003, Kanneliya-Dediyagala-Nakiyadeniya (KDN) was also approved as a Biosphere Reserve. NSF subscribed to the SCOPUS, the world's largest on-line S&T abstracting and indexing database covering 13,500 journal titles, to facilitate literature searches. It provided free access to the full text of journals in the Science Direct Database from 2005.

The Journal of the National Science Foundation, which publishes scientific articles received from scientists, got cited in two databases of the Thompson Scientific Index, BIOSIS Previews and Zoological Records in 2006. This was the only science journal in the country which got cited in the above data bases.

A new segment called 'Vidudora' was introduced to the 'Pahandora' programme of Independent Television Network (ITN) in 2007. Fifteen programmes highlighting achievements of local scientists were produced in collaboration with ITN and telecast on the same tv channel.

Prof. Ananda Jayawardane
Current Director General
National Science Foundation

NSF celebrated its 40th anniversary in 2008 when the NSF-song was launched. This year, the Foundation celebrates its 50th anniversary. Being a premier organization in the science arena, it has contributed vastly towards the development of science and technology in the country. Its future directives which will lead to the establishment of Sri Lanka Bio-Technology Institute and National Science Centre, will provide more experience in science and technology to the people of Sri Lanka.

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The Need to Make Science Popular and Take to the People

K.G. Janaka Karunasena

"Aristotle was wrong" shouted the young Professor of 24 years of age who stood up before his class at the University of Pisa, Italy. He was holding a single brick in one hand and two bricks that he had cemented together, on the other. Then he climbed on to his desk, held the bricks at eye level and dropped the bricks together. The bricks landed at the same time. He repeated this exercise and the result was the same.

This young professor, Galileo Galilei, who was a professor of mathematics at the University of Pisa, Italy, disproved one of Aristotle's central theorems which stated that heavier objects fall faster because they weigh more. "Did the heavier brick fall faster" inquired Galileo from his students who were in front of him. The unanimous answer was "No".

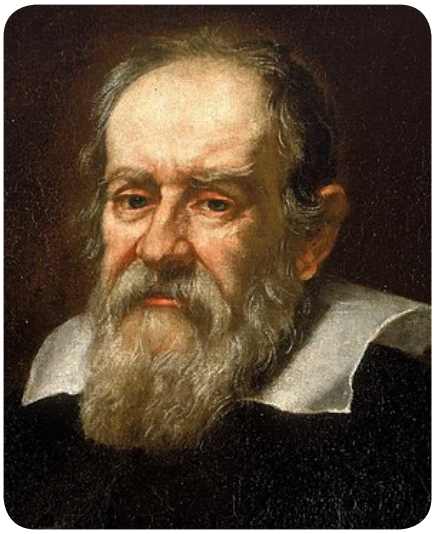

Fig.01 : Galileo Galilei - announced the Law of the falling objects

Galileo used to visit a local Cathedral to sit and think of nagging problems of his mind. He saw that small and large hanging lamps which were used to illuminate the Cathedral gently swing on long chains. Galileo measured the time period of each swing of small and large lamps for several days, and realized that these lamps always swung at the same rate, since they always took exactly the same time to travel through one complete arc. This observation disproved a 2,000-year-old cornerstone belief about the world. This was known as "the law of the falling objects" which Galileo announced in the year 1598.

Galileo's discovery was a paradigm shift, a situation where the usual and accepted way of doing or thinking about an act or activity is dramatically changed.

Changing the concepts of people on the basis of a global – paradigm shift

In the early seventeenth century, almost all educated people concentrated on natural science. Nicholas Copernicus, Galileo Galilei, Johannes Kepler, and Isaac Newton were some of the greatest scientists who lived in the 16th and 17th centuries and who were able to dispute or disprove several beliefs and concept that were in vogue in an earlier era and established by well known Philosophers such as Socrates, Plato, Aristotle *et al.* People believed their pronouncements as the universal truth. All school children who opt to study science were of the belief

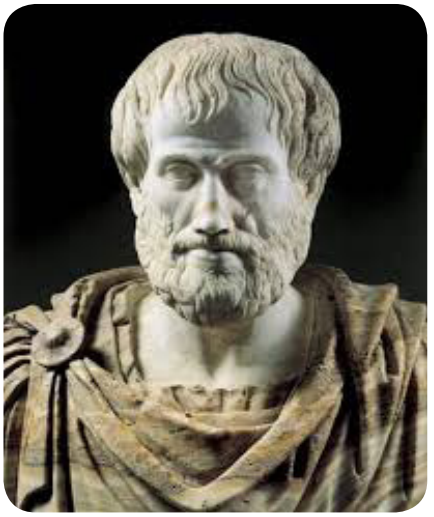

Fig.02 : Aristotle - ancient Greek Philosopher

Fig.03 : Pythagoras - was the first person who proposed that the Earth is round

that the writings of the ancient Greek philosopher, Aristotle, were the foundations of science. However, with the advancement of science, the old concepts and theories were discarded through the generation of new knowledge. Scientific discoveries helped to change the concepts of people of the world. Let us take a look in brief about some of the major paradigm shifts that changed the understanding of the world.

•People in the past thought that the earth is flat and that the sun rotates around the Earth (geo-centric).
•Some believed that forces of nature affected only through physical contacts.
•The same organism was called by different names.
•Another belief was that inflammable material consisted of 'phlogiston', a substance without colour, odour, taste or weight which is released during burning (Phlogiston Theory of Combustion).
•Based on some religious beliefs, people were taught to believe that the age of the earth was 6,000 years.

•Under the same kinds of religious belief, the general public was taught that the human being was a creation of someone invisible to the naked eye. These beliefs underwent change due to great works of scientists.

Pythagoras was the first person who proposed that the Earth was round, sometime around 500BCE. He had based his idea on the fact that the Moon must be round, by observing the shape of the terminator or the line between the part of the Moon in light and the part of the Moon in the dark as it moved through its orbital cycle. Pythagoras reasoned that if the Moon was round then the Earth must be round as well. Then, sometime between 500BCE and 430BCE, a person called Anaxagoras determined the true cause of solar and lunar eclipses - and consequently the shape of the Earth's shadow on the Moon during a lunar eclipse was also used as evidence to show that the Earth was round.

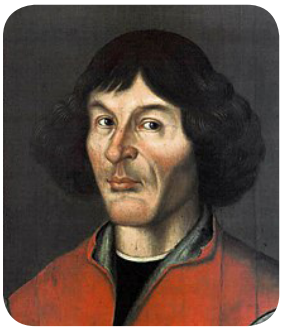

Fig.04 : Nicholas Copernicus - postulated that the Earth revolved around the Sun

With the progress of science over time, a series of paradigm shifts took place. These changes began to occur when understanding of science was effectively communicated to the society.

During the period from 1500 to 1550CE, the first paradigm shift took place in the field of Astronomy when Nicholas Copernicus postulated that the Earth revolved around the Sun (Solar Centric or Helio-Centric), and that the Earth was not the centre of the Solar System (not Earth Centric or Geo-Centric).

Galileo Galilei during the period between 1550 – 1600CE proved that Copernicus was right. He disproved the 2000-year belief on falling objects.

During the period between 1600-1650CE, Johannes Kepler formulated three laws of planetary motion, and stated that planets moved in elliptical orbits and not in circular orbits.

Fig.05 : Johannes Kepler - formulated three laws of planetary motion

Isaac Newton in his book, "Principles of Mathematics" demonstrated that there were universal physical laws (ie. Gravity), which disproved the belief that the forces of nature were only affected through physical contact. This was a paradigm shift that took place during 1650-1700CE.

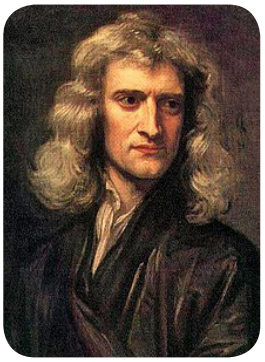

Fig.06 : Isaac Newton - disproved the belief that the force of nature were only affected through physical content

It is estimated that there are four to five million plant and animal

species known on the Earth which differ from one another in external form, internal structure, mode of nutrition, habitats *et al*. Taxonomy which is a branch of biology which deals with identification, nomenclature and classification of organism, plays a major role in studying the diversity of life. Carolus Linnaeus and his students developed a uniform method of naming organisms which is still in use today. It replaced the system of multiple use of many names for the same organism that existed previously. This happened during the period between 1700-1750CE leading to another paradigm shift.

Phlogiston theory of combustion was disproved by Antoine Lavoisier, a French chemist during the period 1750-1800CE. He showed that combustion requires oxygen, and that there is no substance called phlogiston in materials. According to the phlogiston theory, inflammable materials consist of a substance called "Phlogiston" and ash. The new theory said that something called oxygen came out from the air and was added to a material while it was burning.

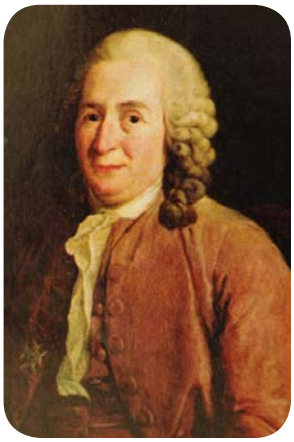

Fig.07 : Carolus Linneus - developed a uniform method of naming organisms

Fig.08 : Antoine Lavoisier - disproved the plogiston theory

Hutton's theory during 1800-1850CE, which led to another change in the way of thinking of the society, enunciated that the age of the Earth was much older than 6,000 years as was believed.

Charles Darwin's research on natural selection and evolution (1850-1900CE) and his book on the same title, revolutionized the way people thought about the origin of the human species.

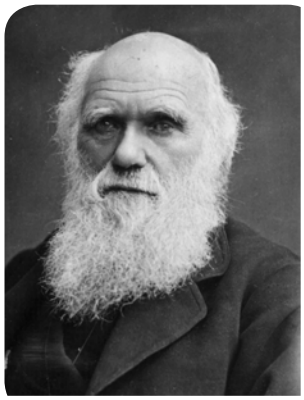

Fig.09 : Charles Darwin - changed the way people thought about the origin of human species

The period between 1900 – 1950CE was the era that focused on physics, especially on the nature of matter. During this period Albert Einstein became a key figure due to his theory of relativity, which caused a paradigm shift in relation to the relationship between matter and energy which were interchangeable. This improved the understanding on matter which provided the basis of nuclear physics, and which led to atomic power and atomic bombs.

A paradigm shift that took place during 1950-2000CE was due to the elucidation of the structure of DNA (Deoxyribonucleic acid) by James Watson and Francis Crick. Consequently the advancement of the molecular biology led to biotechnology, the human genome project, and the new insight into the evolutionary relationship of living things.

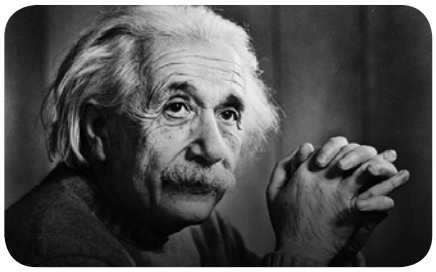

Fig.10 : Albert Einstein, became a key figure during 1900-1950 due to his theory of relativity

Commencing from 1500CE, around ten major paradigm shifts occurred within the past 500 years. These findings of great scientists were disseminated especially among educated persons, which led to a visible change in the way of their thinking about many things. It did not limit to the country where it originated, but is known among educated people of the world due to its dissemination and popularization of new knowledge, which is necessary for a better understanding of the world.

Popularization of Science – the need of the day

Science is the study of the nature and behaviour of natural things and knowledge we obtain about them. In other words, science is the systematic study to resolve identified problems using the scientific method. People involved in scientific research and experimentation are called as scientists. "Science" comes from

a Latin word which means "knowledge." Scientists create knowledge which must be transmitted to the people. Scientists and researchers create knowledge by doing research and experiments applying scientific method to solve research problems. Engineers make technological developments to provide more facilities to the people to make their life easy. Modern science began in the 16th century and thereafter a rapid development took place in the arena of scientific research. Science contributed many benefits and achievements to the society to improve life expectancy by improving of health conditions, increasing of crop productivity to improve food production to feed the rapidly increasing world population, control of diseases and many other scientific discoveries. In order to reduce absolute poverty and improve the economy, intervention of science and technology is vital. Developed countries achieved their status mainly due to use of science and technology in their development processes. Such achievements can be met only if the entire population is aware of modern developments in science and technology,

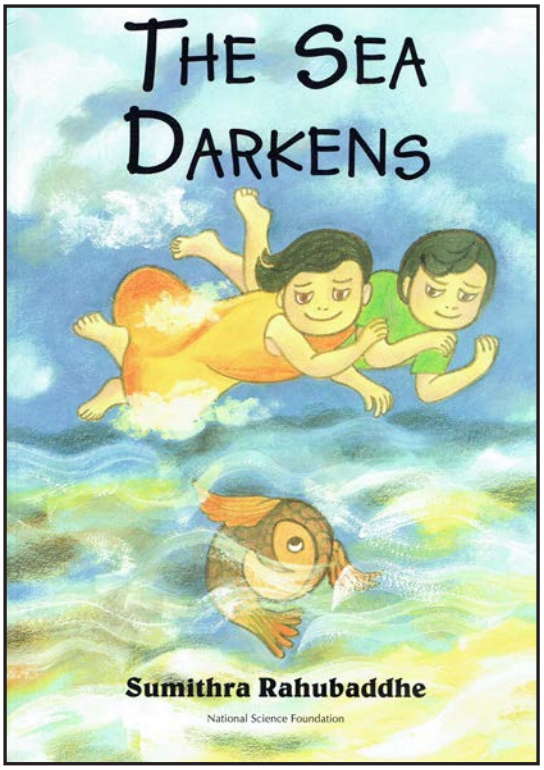

Fig.11 : The Sea Darkened - a children's story based on Tsunami

and are trained to apply the basic principles in everyday life. Increased food production, effective family planning, improved sanitation and hygiene, a cleaner environment, and efficient use of water and energy resources are essential elements that can be achieved with scientific literacy. If the majority of the people are illiterate, it is not easy to convey the message of science through the printed media. The electronic media such as radio and television assume great importance. Innovative approaches are often necessary to reach a wide audience as possible. Hence, it is of vital importance to popularize science which should be carried out among the general public through the support of the school community, Editors of print media, News Editors of the electronic media, Policy Makers and Political Leaders.

Making Science popular via publications

Some of the books which popularized Science and gave people new scientific knowledge were as follows - 'On the Revolutions of Heavenly Spheres' by Nicolaus Copernicus (1543CE); 'Dialogue Concerning the Two Chief World Systems' by Galileo Galilei (1632CE); 'Mathematical Principles of Natural Philosophy' by Isaac Newton (1687CE); 'The Voyage of the Beagle' (1845CE), 'The Origin of Species' (1859CE) by Charles Darwin, 'Radioactive Substances' by Marie Curie (1904CE); 'Relativity: The Special and General Theory', (1916CE), 'Ideas and Opinions' (1954CE) by Albert Einstein; 'The

Fig.12 : NSF published a series of books and booklets to popularize science

Double Helix' by James D. Watson (1968CE) and 'A Brief History of Time' by Stephen Hawking (1988CE.)

National Science Foundation (NSF) which came under the Science and Technology Development Act 1994 with funding programmes to popularize science amongst the people is the only organization which has a separate Division, a trained staff and allocated funds towards the popularization of Science. Towards this, a series of children's story books on scientific information, Science books and booklets on scientific topics and concepts are published. The NSF Science Magazine – **'Vidurava'** is published in all three languages of which the goal is to take science to the people.

"The Sea Darkened" (*"Muhuda Kaluvuna"*) was a publication authored by Ms Sumithra Rahubadda on a request made by NSF, which was a children's story based on the Tsunami of 2004 CE written in order to make children aware of natural disasters which can have a devastating effect on people and property. This book with illustrations by Ms Sybil Wetthasinghe was published in all three languages by the NSF, which subsequently won a State Literary Award in 2006 CE under the category of children's stories. The book was distributed among schools registered with NSF and those in areas affected by the Tsunami.

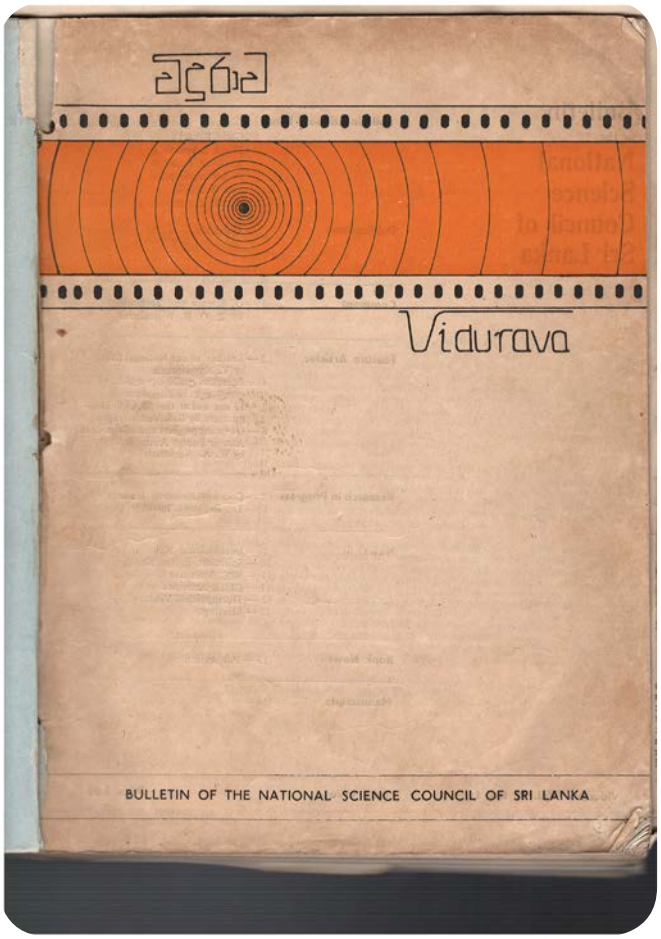

Fig.13 : The first issue of the Vidurava (Science Bulletin), 1976

A series of science books and booklets written in simple language have been published by NSF and distributed among schools free of charge. The Sinhala translation of "Mathematics can be fun" written by Y. Perelman was republished 5000 of its copies were distributed free of charge along with a series of other science booklets written by local scientists, among schools with underprivileged children.

Further, NSF introduced a new Grant scheme to provide financial support to science authors to write on a range of topics in science and technology, for the purpose of popularizing science and to encourage potential writers to publicize useful information on science and technology. Authors of this scheme, are provided the cost of typesetting, page designing, page setting, editing, proof reading, preparation of the final camera ready copy and printing of their science publication subjected to conditions such as financially it should be done under a maximum ceiling of Rs. 500,000/- with copies restricted to 200. Manuscripts should be sent to NSF with a duly completed application form which can be downloaded from the NSF Website (www.nsf.gov.lk). Guidelines for the applications are given in the website.

The publication of science magazines began during the nineteenth century with science magazines becoming popular and expanding in number during the latter part of the nineteenth century. Science in print also became increasingly influential. A science magazine is a periodical with news, opinions and reports on science, generally written for a non-expert audience. In contrast, a periodical which generally includes primary research and/ or reviews, and written by science experts is a "scientific journal". Science magazines are read by non-scientists as well as scientists who wish to access information on fields outside their own fields of specialization.

The Birth of Vidurava Science Magazine

"Science," "Scientific American," "New Scientists" are some of the well known science Magazines which are published with the intention of bridging the gap between science and the people. The NSF (then National Science Council) began the publication of "Vidurava Science Bulletin" of National Science Council in 1976 to cater to the need for scientific information of the Sri Lankan people. Later, it was renamed **"Vidurava Science Magazine"** and was published in Sinhala, Tamil and English in order to disseminate science in local languages. Until 2017, it was published thrice per year, in January, June and November, but from 2018, it has been published as a quarterly publication.

Vidurava is published on a current scientific theme decided by the NSF Working Committee on Science Popularization. Scientists, researchers and specialists in respective fields are invited to write in on given topics related to the specific theme provided by NSF.

The Magazine is distributed free of charge among the stakeholders which include School Science Societies registered with NSF (SSS; 848 numbers), Vidatha Centres (VC;240 numbers), University Science Societies (USS;49 numbers), University Science Libraries (USL;29 numbers), Provincial Science Coordinators (PSC; 09 numbers), and Zonal Science Directors (ZSD;98 numbers.) Accordingly, 1,328 stakeholders receive Vidurava annually (Fig.14). This will be gradually increased with the increase in the number of school science societies registered with NSF.

Ways of making Science popular for effective communication of Science

In the early years, scientists themselves published and communicated their work among the public. After the Second World War, they were replaced by professional science communicators. However, there still was a shortage of trained science communicators to bridge the gap between science and the general public. There were very few skilled science communicators in the country as well as in the global arena. Identifying this need, NSF launched a programme to train local scientists as science communicators by organizing a three day Workshop to train the trainers of science communication. Two veteran science communicators - Prof. Bala Subramanium and Dr. Bal Phondke, from India were invited as resource persons for the residential workshop held in Colombo and it trained thirty scientists as trainers. Thereafter, a series of training workshops were organized at Lunuwila (Coconut Research Institute; CRI), Kandy (National Institute of Fundamental Studies; NIFS), Anuradhapura (Rajarata University), and at Kuliyapitiya (Wayamba University), and at its conclusion, the expected target was achieved. NSF continues this exercise of organizing Training Workshops on Science Communication for the scientific community.

University Science Societies as conduits for science popularization

Science Faculties are excellent and centres where science is taught. Undergraduates gain knowledge from various disciplines of science.

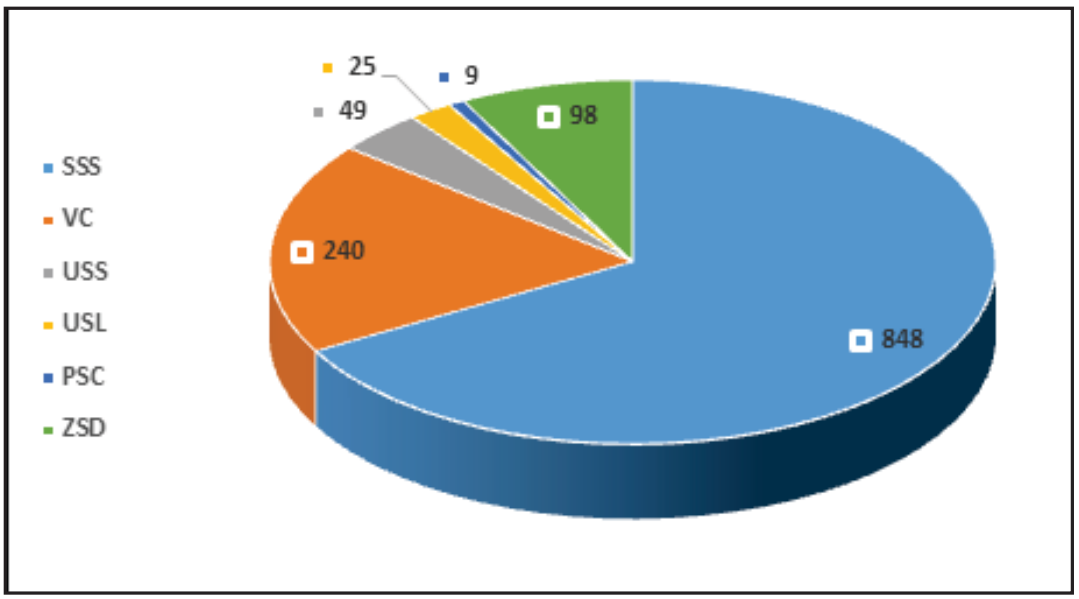

Fig. 14: Distribution of the Vidurava among stakeholders during 2017

They have formed different science societies such as "Astronomy Society", "Animal Science Society", "Bot-Soc" *et al*. These societies are registered with NSF with the objective of popularization of science. There are 49 such University Science Societies registered with NSF at present. Senior Treasurers can register their societies with NSF, and registration is free of charge (Application and Guidelines are available in the NSF Website). Various workshops and competitions have been organized by NSF for the members of University Science Societies. They receive Vidurava Science Magazine free of charge from NSF.

Use of the school community for popularizing science

In developing countries, science clubs and science societies play a major role in popularizing science among the school community and the general public. In order to foster scientific activities in schools in the country a special programme called School Science Society Programme-SSSP was established at NSF in the year 2005. The objective of this programme was to register school science societies with NSF to facilitate them to acquire knowledge on latest developments in various fields of Science and Technology and to make them aware of application of scientific knowledge in day-to-day activities. Initially, 1 AB schools or schools having A/L Science Stream were registered in the year 2005 which numbered 134 schools out of 625. Thereafter, it was extended to other categories such as Type II Schools having Arts and Commerce Streams and I C or Schools with Classes up to O/L. The total number of schools registered with NSF as at 30 June 2018 has gone up to 903

These societies are fostered by NSF to popularize and promote science within and outside the schools. They benefit by receiving the services of local scientists when science days are held and for other science popularizing activities of which the costs are borne by the NSF. They receive the *Vidurava Science Magazine* free of charge regularly and opportunities are open for them to participate at competitions such as Inter School Science Society Competition, Science Research Project Competition, Sri Lanka Science & Engineering Fair, Intel International Science & Engineering Fair held in USA *et al*, as well as participate in programmes such as NSF School Science Day, workshops which are organized by NSF. Further, they are eligible to apply for financial support to organize science popularization and science education programmes in schools under the Science Education and Popularization Programme (SEPP) Grants Scheme, and to participate at international science programmes and competitions under Overseas Science Education Programme (OSEP) Grant Scheme.

Interested schools are invited to apply for registration under the SSSP of NSF by sending an Application form which can be downloaded from the NSF Website; www.nsf.gov.lk and addressed to the Director General. This is done free of charge.

The performance of registered school science societies with NSF is gauged annually with the award "Five Stars" given for the best performing schools, are felicitated by awarding plaques, certificates and cash awards at the NSF School Science Day.

Grant Scheme for Science Education and Popularization Programme (SEPP)

This programme which was initiated in 2016, facilitates the organizing of science popularization and science education activities through financial support under two categories; one, the provision up to Rs. 200,000/- for science popularization programmes and the other provision to a maximum of Rs. 1,000,000/- for science education programmes in schools and Universities.

Grant Scheme for Overseas Science Education Programme (OSEP)

The objective of this programme is to provide international exposure on trends in modern science, technology, research and innovation, to Sri Lankan school children, teachers and university undergraduates. This is in order to upgrade and improve their knowledge base in these areas to enable them to face challenges of the modern world. Under this programme, a maximum of Rs. 200,000/- will be provided per person.

More effective ways of popularizing Science

Current trend in science popularization is the use of modern technology such as IT, IOT, Mobile phones et al; Science fictions, films,

Fig.15 : "e" Swabhimani Special Merit Award and the "Manthan" Award South Asia won by the "Mihimandala" Phase I in 2011

TV programmes also play a major role.

Consequent to the major disaster to the nation by Tsunami in 2004, NSF planned Awareness programmes on natural disasters as well as on other current scientific issues to enable people to be informed in their day to day activities. A series of short video programmes was produced in two phases and transmitted through national TV channels-Independent Television Network (ITN) and Channel Eye of Sri Lanka Rupavahini Corporation to take the message to the people. This video series named "The Mihimandala" and 13 video programmes in all three languages were produced under Phase I. And 15 video programmes were produced under Phase II. The Sinhala version of the video programmes produced under Phase II are at present aired on *Rupavahini*, The Tamil version are shown on *Nethra* and the English version on *Channel Eye*. Phase I of *"Mihimandala"*, was a very successful series which won a national award *"e-Swabhimani"* Special Merit Award from ICTA. *"Manthan"* won the international award for South Asia from Digital Empowerment Foundation, New Delhi, India in 2011. This was the first international award offered for a programme organized by NSF in its history.

Taking science to people through competitions

Many countries organize science competitions in various forms. Intel International Science & Engineering Fair (Intel ISEF), Google Science Fair, International BioGENEius Challenge, MIT THINK Scholars program are some of the most prestigious Science Competitions in the world. NSF along with three other stakeholders commenced organizing the Sri Lanka Science and Engineering Fair (SLSEF) from the year 2008 as the affiliated National Fair of the Intel ISEF, USA. This National Fair provides a platform to the top ten science projects selected through the Science Research Project Competition (SRPC) organized by NSF and the top ten inventions selected through the Junior Inventor of the Year (JIY) competition organized by The Institute of Engineers Sri Lanka which enable them to compete at the Intel ISEF, USA. Three winning projects are selected at this National Fair which gives them the opportunity of participating at the Intel ISEF, USA.

Among the past winner who won international awards at Intel ISEF are, Lochana Piyumantha Fernando, Senanayake National School, Madampe. He won the Special Award of US $ 1,000/- from Intel ISEF, Arizona in 2016, Shehan Kavishka and Sankalpa Perera of S. De S. Jayasinghe MahaVidyalaya, Dehiwala won the Special Award of US$ 1,000/- & the forth place in the Grand Award - US$ 500/- from Los Angeles in 2017. K.R.R. Induwara of Ananda National School, Chilaw won the third place in the Grand Award - US $ 1,000/- from Pittsburgh in 2018. They who brought glory to the country were trained by NSF under the SRPC.

Lochana

Shehan & Sankalpa

Iduwara

Fig.16 : School children who brought glory to the country trained by NSF under the SRPC

Keep School Science Societies alive, a competition among Science Societies had been organized annually since 2006. In order to take the message of Science to the school community this competition had been conducted annually under the same scientific theme of the NSF School Science Day. Short science drama, the role of a scientist, viridu, manual posters, digital storytelling, science essays are components of this Competition. When preparing for the competition, students are given the incentive to read books to find facts and information on the theme, search the internet and hold discussions with their teachers. In each of these schools, teachers of science, drama and music together with the children work jointly as a group and make an effort to win the competition. What is important is that through each component of the Inter School Science Society Competition, scientific message relevant to the theme is conveyed to the society. The combination of science, drama and music is also described as a mixing of science with art (STEM plus art).

Conducted annually for just over a decade, the competition provided an opportunity for school children and teachers to exit from the bookish mentality and to think out of the box.

Teachers are the backbone of high performing School Science Societies. They guide students and involve them in various scientific activities in their schools. With the objective of encouraging them for continuous involvement in scientific activities, NSF awards "The NSF Award for Promoting Science among the School Children." The competition for the above Award is organized annually through the Inter School Science Society Competition-an event announced to the schools through Principals. The winning teachers are awarded plaques, cash awards, and certificates during the NSF School Science Day Programme.

In order to popularize science among the people, prestigious Award had been offered by the NSF named "Prof. M.T.M. Jiffry Memorial Award for Popularization of Science among the People". Many prestigious international Awards for popularization of science exist such as Carl Sagan Prize for Science Popularization (for scientists) and UNESCO Kalinga Prize for the Popularization of Science (for any person who popularize science). Prof. Jiffry Memorial Award is open to citizens of Sri Lanka who have contributed towards science popularization. The annual Award of Rs. 100,000/- is given to a person on the basis of once in his lifetime.

NSF, being the focal point of Science in Sri Lanka has contributed immensely to support the popularization of Science among its citizens through funding programmes designed for such purposes.

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Technological Skills to Win the World

J. G. Shantha Siri

Technology is the key for socio-economic development

Technology can be regarded as the key for economic development of a country. Successive technologies and innovations in the past have contributed towards the development of underdeveloped countries. The fourth technological revolution in the platform of technology will be characterized by many forms of technology or multidisciplinarity through the entry of digital, physical and biological technologies. Only countries which have prepared themselves to infuse this new technology and take advantage of this technological revolution will be able to rise above the rest.

Technology at present, is a vital element in globalization and competitiveness. It has brought wealth to nations, companies and individuals and studies of varied subjects show that there is a positive correlation between technological advancement and economic growth. According to Robert Solow, the technological change accounted for about 2/3rd of growth of the U.S. economy. Three pillars out of 12 in the preparation of the 'Global Competitiveness Index Report" published by the World Economic Forum are higher education and training, technological readiness and innovation. This indicates the significance of technological skills, innovation, and technological sophistication to enable a country to emerge as a globally competitive nation.

One of the key strategies in the national development agendas of emerging economies (BRICM countries) and newly industrialized countries such as Malaysia, Thailand and Indonesia was to enhance technological capacity and sophistication by means of importing foreign technology, reverse-engineering, transfer of cross border technology, technology licensing, backward linkages with foreign companies and foreign direct investment (among others) *etc.* Eventually, they have been able to win the global market by introducing competitive products to it, thereby contributing significantly to GDP through high tech exports. However, a country cannot continue to depend on foreign technology alone. A nation that invests more on scientific and technological research will tend to develop faster than countries that depend on accumulating more capital but investing less on Research & Development and development of technology. Inventions and innovations have also significantly contributed for rapid economic growth in a given country. This is clearly evident from fig.01 which shows how China's patent profile with its exponential or rapid growth through the year 2015 had overtaken the USA and Japan.

Challenges for developing economies to retrace a rapid economic growth

New technological developments such as computer modeling and simulation or imitations, have speeded up understanding of science and the process of research and development. Accordingly, the time interval between the conception of an idea and its transformation to a marketable product as well as recognition as a scientific discovery to commercial application, is decreasing. Modern ICT has also facilitated the retrieval of new knowledge and its

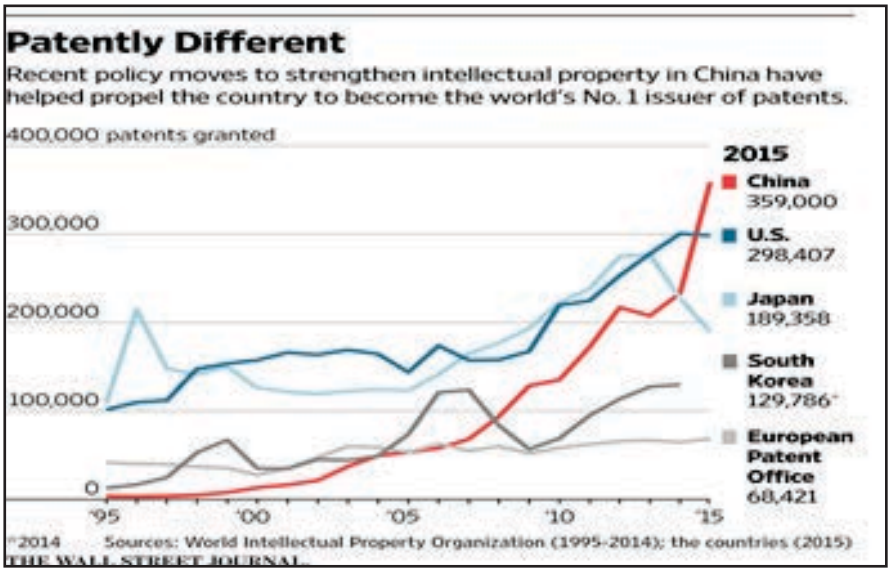

Fig.01 : Patent profile of some of the leading economies

dissemination. Hence, imparting the workforce with knowledge and skills on computer modeling and simulation through ICT and other emerging technologies, will enable them to tap the rapidly growing global knowledge or global talent pool and thereby be part of the global value chain to gain benefits for the country. When analyzing global trends in trade, it can be clearly seen that production and introduction of medium to high technologically manufactured exports have been increasing over the past few years. Hence, if a country continues to export primary commodities, it will lose the competitiveness as well as global market opportunities eventually. Therefore, enhancing technological capability and skills supported by more investment in Research & Development to manufacture and export high technology goods is an absolute necessity. Implementation of international trade agreements such as GATT (General Agreement on Tariffs and Trade), level of tariff and non-tariff barriers have failed in many countries. Developing countries have liberalized their trade policies particularly to attract highly skilled labour from around the world in selected disciplines. This indicates magnitude of importance of technological skills for a nation to become globally competitive. Sometimes, such international trade agreements tend to bring a competitive pressure even to the domestic markets. Therefore, the challenge for the developing countries is to formulate appropriate strategies to regulate the level of openness to global competition at the same time while nurturing their own skills and development towards production of globally competitive products/ services.

Re-determining national policies on educating and skill development of youth

It is instructive for the workforce to acquire and upgrade their technological skills not only to contribute to the knowledge economy but also to enable them to grasp emerging economic opportunities in the global market. Transformation of the labour force into a skilled workforce should not be a static or slow process, it should also be highly adaptable, flexible and responsive to the global needs and the changing environment. Skill development takes place through informal and formal mechanisms. Carrying out a systematic analysis is worthwhile to determine whether the existing skill development schemes are adequate to face global challenges effectively or whether revisions are needed to cater to national and global needs. Accordingly, a national level skills development initiative will be required to upgrade skills to be on par with international standards and to be responsive to the demand of innovation.

Education leading to creation of knowledge is as important as application and technological skill-development

Technology and innovation driven development is not just the creation and use of new knowledge. It also requires quality of education, training, technological skill-development, networking with institutions, intellectual property protection, learning of new technology of foreign countries and public-private partnerships in order to show people's knowledge. For example, the Republic of Korea invests mostly in Research & Development as well as in higher education. It is interesting to see the case of Singapore on how it leapfrogged from a cheap unskilled labour market to a leading knowledge based economy. Singapore attracted foreign investment by investing heavily on secondary and technical tertiary education,

thereby upgrading technological skills of the workforce to remain competitive. Malaysia and Thailand being newly industrialized countries have invested more on Research & Development as well as on education, particularly in tertiary education. It is important to think not only on Research & Development and creation of new knowledge, but also it is necessary to have strategies and negotiation skills, adaptation and assimilation of new knowledge which prompts the necessity to have a human resource base with relevant technological skills. Even adaptation of technology to suit local conditions needs personnel with relevant skills.

Research and Development leading to inventions and innovation however, is not a simple process. It needs a range of skills which include, technology assessment, negotiation skills, economics, technopreneurship, intellectual property considerations, social science, law, fiscal measure such as duty payment and taxation and more importantly deployment of personnel with Research, Development and right qualifications and experience and skills at the right time.

Another example of harnessing technological skills to win the world is Taiwan. Taiwan had a strong industrial and trade policy in which they promoted import substitution within the country through tariff and non-tariff barriers. Taiwan's technology and industry strategy was so robust that enabled the country to attract expatriates working in high-tech industries around the world. This deployment of persons with right skills enabled Taiwan to transform itself from an electronic assembling country to a chip manufacturing country and become its own brand player in the global market.

India was globally recognized for its engineering talents which generated highly skilled software engineers. India has been able to attract globally renowned multinational companies (MNC) to establish MNCs supported with advanced Research & Development centers, demonstrating the availability of high level human capital within the country.

China's technology and trade strategy was directed at promoting FDI, while leveraging its own innovations with enhanced investment in Research & Development. China has also invested in human capital like Japan and Korea. Therefore, the secret behind China's super-power success in innovation driven economic development was the human capital factor with right technological skills.

NSF Technology Grant Scheme and Technology Innovation Support Center (TISC) foster technological skills and capacity

The Prime objective of the NSF Technology Grant Scheme "Support for Technology Development (Tech-D)" is to foster Research & Development findings, commercialization, technology development and for technology driven innovation for technological competitiveness towards socio-economic advantage of the country. It provides financial support for researchers and inventors to take their research outputs/ inventions which have commercial potential beyond laboratory levels to marketable level. This grant scheme is open for state sector organizations such as Universities and Research & Development institutions, non-state sector (industry) and individual researchers and inventors. It also promotes harnessing of our technology as import substitutes, reverse-engineering, technology adaptation and technology transfer. The researchers and inventors are always encouraged to carry out their technology development projects in collaboration with the relevant industry to ensure synergy. This grant scheme not only facilitates enhancement of technological skills of different individuals in the innovation ecosystem, but also it upgrades innovative capacity of institutions and industry. More information on the grant scheme is available on www.nsf.ac.lk/index.php/researchers-a-academics/tech-d-grants/212.html.

In the context of knowledge economy, Value of Intellectual Property (IP) has seen an increase. Therefore, building knowledge and skills on acquisition of IP followed by commercial exploitation, are necessary and timely. The TISC Center of the NSF provides guidance for researchers, inventors and technology developers on patent information search, patenting process, patent drafting, patent filing, and even applying for patents under Patent Cooperation Treaty (PCT). They can also seek and acquire knowledge on preparing non-disclosure agreements, technology licensing agreements as well as conducting technology transfer/licensing negotiations. The services provided by the TISC Center enable researchers and inventors

facing challenges in protecting and commercializing their own IP to be served effectively.

Success story of NSF
NSF Technology Grant Output delivers Value Added Healthcare Services with "e-Health KIOSKS": Benefits for patients with Modern ICT

Health information systems and healthcare practices in Sri Lanka largely rely on paper work and manual procedures that are often complicated and time consuming. At present, regardless of government or private healthcare, patients have to visit hospitals and stay long hours in queues to obtain a channel number and consult a doctor. This is a very inconvenient practice and has led to frustration among patients. Besides, especially during peak hours, it is difficult for the hospital staff to ensure quality healthcare-delivery as they have to attend to the needs of patients individually. Administrative costs of hospitals are also high because of the heavy dependency of documentation and time consuming process in the existing healthcare practice. Therefore, many enterprising institutions are focusing attention on developing e-Health devices (i.e. self-service kiosks) as a solution to these problems. East Link Engineering Company (Pvt) Ltd with financial support under the Technology Grant Scheme of the National Science Foundation (NSF) has invented an e-Health solution titled "e-Health KIOSK" to address such problems in Sri Lankan healthcare industry.
"e-Health KIOSK" automates routine activities of Sri Lankan healthcare sector covering patient-check-in, consultations with

Fig.02 : e-Health KIOSK developed with NSF financial support

doctors and the completion of prescriptions at hospitals. It is an interactive self-service system designed for public use for delivery of information on channeling services, OPD services, clinic services, specialist care services, visits of doctors, consultation hours, channeling charges et al without having to wait in hospital queues for registration and the like. This tool thus improves the quality of healthcare services and bring satisfaction to patients. Facilities of this device is also extended to a level where a patient can make payments for channeling services, payments to the pharmacy or obtain test reports through an e-Health KIOSK. In addition to the services to patients, e-Health KIOSK also provides a series of benefits to hospitals by way of reduction of administrative costs and paper work, saving valuable hours of the day of the working staff, a better management of patient-queues, enhancing communication efficiency, quality of care, improving data quality and safety as well as establishment of consistency of healthcare service, progress and effective management decision-making.
As a result of its special benefits, there had been a great demand of the e-Health device from both government and private hospitals. Two e-Health KIOSK machines, developed by the East Link Engineering Company (Pvt) Limited with financial support of the NSF are deployed at the Nawaloka Hospitals PLC and the Colombo National Hospital.

Ensuring equity and sustainability
Disruptive technological changes have macroeconomic impacts on productivity, growth as well as on inequality, human health and safety of the environment. Such situations have occured in some of the emerging economies. Therefore, it is vital to be cautious when formulating development agendas in order to ensure that innovation driven development is economically sound, socially responsible and environment friendly.

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International Liaison to Develop Science in Sri Lanka

Wasantha Anuruddha

With the new technological development taking place in the globe, the scientific world simultaneously is fast becoming interdisciplinary. Therefore, it is necessary to connect the world through sciences. The use of scientific collaborations among the nations to address common problems has become imperative. Therefore, building international liaison has become an important topic today.

Realising this factor, the government of Sri Lanka has turned to invest not only on infrastructure development but also for the capacity development for Science and Technology (S&T) personnel. As a result, bilateral agreements were signed with Pakistan, China, Japan and Germany.

In 2016, the government of Sri Lanka organized a forum on the subject of Science and Technology for Society (STS) with the objective of exploring opportunities for the Sri Lankan society from the global S&T Developments. Therefore, it is encouraging to note that gradually the Government has accepted the importance of S&T for socio-economic development of the country. Taking this as a positive signal, we as a society should work together to convince the Government to increase the investment to 1% of GDP towards research while making efforts to convince scientists and technologists to deliver the desired output to the society. The authorities need to take the initiatives to involve scientists and provide adequate funding for Research and Development (R & D.) All the scientists need to work in local and international networks in their respective discipline of science for the benefit of the society.

National Science Foundation (NSF) having noticed the importance and the current trends in the global arena enhanced creating new networks with several countries. This is in order to strengthen the cooperation in the areas of S&T. So NSF will promote and enhance capacity building through liaising with individuals, associations or institutions locally and internationally which hopefully will facilitate the return of Sri Lankan scientists and technologists of distinction for S&T development.

International Grant Schemes

NSF in order to facilitate scientists and technologists and also to enhance their knowledge related to S&T as indicated above, has introduced Grant schemes. This is to help them to exchange and obtain information and enable them to network. The International Liaison Division (ILD) at NSF coordinates the following schemes.

1.) Travel Grant Scheme (TG)

2.) Overseas Special Training Programme (OSTP)

3.) International Partnerships for Science and Technology (IPSAT)

4.) International Collaborative Research Programme (ICRP)

5.) Overseas Science Education Programme (OSEP)

The Travel Grant Scheme provides an opportunity to Sri Lankan scientists and technologists to present and share the research findings at International fora and to acquire knowledge and skills on new discoveries, achievements and developments in their respective fields of research. It also provides an opportunity to get exposure at global level and to establish links with scientists worldwide working in similar research areas for future collaborations.

OSTP enhances national capacities by providing opportunities for training and acquiring advanced laboratory skills which are not available in Sri Lanka in the foreseeable future, industrial experience and international exposure to scientists and technical personnel in academia, research institutions, government bodies or industry and for media personnel in relevant institutions.

IPSAT scheme is to facilitate Sri Lankan scientists, engineers, science and technology policy makers and research personnel, to undertake collaborative R&D/S&T service assignments with foreign based scientists for stipulated periods in Sri Lanka. This is to encourage our scientific community to have international research collaborations, technology transfers and also promote in obtaining expertise towards developing globally-engaged research in Sri Lanka.

The NSF introduced International Collaborative Research Programme (ICRP) to shift the collaborative research among Sri Lankan scientists, engineers and social scientists to go beyond the boundary of Sri Lanka towards international arena so as to connect and to carry out joint research programmes with their counterparts.

The OSEP scheme provides international exposure on trends in modern science, technology, research and innovation to Sri Lankan school children, teachers and university undergraduates to upgrade and improve their knowledge on science, technology and innovation to face the challenges of the modern world.

The following Table illustrates as to how the NSF awarded Grants to the scientific community in the country. It shows the gradual increase of the number of awards and thereby the benefits the scientific community had reaped from these schemes.

Multilateral and Bilateral Co-operation

The bilateral and multilateral programmes are aimed at developing research cooperation among countries, funding organizations and to improve

Table 1 - Number of Grants awarded

	Number of Grants Awarded		
Year	Travel Grant	OSTP	IPSAT
2012	36	17	1
2013	43	19	3
2014	51	16	3
2015	41	16	3
2016	63	44	15
2017	60	38	11

Fig.01 : NSF Global partnership

quality of research in the country while encouraging the networking on scientific cooperation among them.

As such, NSF has established bilateral and multilateral cooperation with the objective of increasing and developing international scientific relationships. The aim of these programmes is to provide opportunities to the Sri Lankan scientists, academics, researchers and technologists to enhance their knowledge and to be on par with the international counterparts. These schemes will enable them to obtain new knowledge and training in S&T which will open out to international joint research programmes.

Bilateral Co-operation

In recent years NSF has given increased attention to bilateral scientific cooperation with the intention of enhancing S&T capacities and capabilities of our scientists. NSF organized a few meetings on Bilateral Scientific Cooperation under the theme 'NSF Global Partnerships' with scientists from USA, Canada, Germany, China and Japan, in September 2016 in Colombo.

The main objective of these meetings was to discuss research systems and opportunities available in their countries for collaboration with Sri Lanka. Further, NSF identified key activities which could be conducted in collaboration with the above countries. Some local scientists who had already established collaboration with

Fig.02 : Signing the agreement with Pakistan Science Foundation

Fig.03 : First workshop between NSF and NSFC (National Natural Science Foundation of China)

these countries were also invited for these meetings. Consequently, NSF was able sign Memorandums of Understanding (MOU) with some of these countries.

Under the MOU signed with the Pakistan Science Foundation (PSF) in 2016 NSF was able to provide opportunities for Sri Lankan scientists to initiate collaborative research programmes with joint co-funds from both institutes for their respective research areas.

With the aim of resolving issues of livelihood i.e. water security, CKDu, NSF with National Natural Science Foundation (NSFC) held the first joint workshop in Beijing, China in July 2017 under the theme "Climate Change Adaptation, Environment and Health" and subsequently called joint research proposals for co-funding by the both institutions. NSF signed the MOU with NSFC in 2016.
Further, NSF signed a Memorandum of Cooperation (MOC) with Japan Science and Technology Agency (JST) in 2017 and currently is organizing joint research programmes following the Joint Workshop held on the theme "Genetic Resources in Livestock Farming and Agriculture." Some scientists and researchers related to these fields from both countries will participate at this Workshop which will be held in October this year.

In addition, NSF signed a MOU with the German Academic Exchange Service (DAAD) in April this year which will benefit higher education and research sector. As such, the Project-based Personnel Exchange (PPE) can be utilized to improve the quality of researchers in the Universities and higher education in the country.

Multilateral Co-operation

With regard to the multilateral scientific cooperation, NSF plays a control role as the focal point in Sri Lanka for many international scientific bodies. Among them Sri Lanka works very closely with the following organizations.

a.) International Centre for Genetic Engineering and Biotechnology (ICGEB)
b.) International Science Council (ISC)
c.) The World Academy of

Science (TWAS)
d.) Global Research Council (GRC)
e.) UNESCO Programmes
f.) Science Council Asia (SCA)

Sri Lankan scientists have been provided opportunity to submit research proposals under ICGEB Collaborative Research Programme (CRP) and Early Carrier Research Grant scheme annually. Further, at the ICGEB Board of Government meeting in 2018 Sri Lanka was given the opportunity to present the proposal on ICGEB Regional Research Centre (RRC) for south Asia which is proposed to be established in Sri Lanka. Accordingly, the MOU is under consideration for signing. Another MOU is to be signed between ICGEB and NSF on co-funding work on allowance for Research Assistants under ICGEB CRP grants.

Activities under the ISC, NSF intends to work on sustainable development, climate change *etc*. Ministry of Science, Technology and Research signed a MOU with the European Organization for Nuclear Research (CERN) in 2016 for which NSF provided funding for Sri Lankan students during this period to participate at the Summer Students Programme in CERN, Geneva.

The NSF concord with The World Academy of Sciences (TWAS) have been awarding the TWAS Young Scientist prize annually for the talented young scientists who have attained high level of excellence in research work, in the fields of Biology, Chemistry, Mathematics and Physics. The award consists of a cash prize and a certificate.

The Man and the Biosphere (MAB) Programme was a direct outcome of the UNESCO – Biosphere Conference in 1968 and in Sri Lanka it was launched in 1971. The National MAB Committee is hosted at National Science Foundation. The MAB Programme is an Intergovernmental Scientific Programme that provides a scientific basis for a healthy relationship between people and their environment. It combines natural and social sciences, economics and education, to improve human livelihoods and safeguard natural ecosystems, develop natural resources thus promoting innovative approaches to economic development that is socially and culturally appropriate and environmentally sustainable.

Together with New Zealand Ministry of Business Innovation and Employment, the NSF co-organized the Asia Pacific Regional Meeting of the Global Research Council (ASPGRC) in November 2017 in Colombo. Thirty-seven delegates representing research funding organizations from twenty countries took part at this meeting. "Science Diplomacy" and "Peer Review" were the two themes discussed at this meeting. Recognizing the role play in advancing science, addressing global, regional and national interests and issues and the important role the GRC already plays in science diplomacy, the delegates supported the concept. Science as tool for diplomacy has been used for several decades by many countries around the world to bridge the world through science. "Science for Diplomacy" is one of the activities where scientific cooperation can improve international relations. Many of the challenges related to health, economic growth, climate change *etc*. in our country will be addressed through international relations. Therefore, our scientists, technologists, research institutes, universities with the government and the private sector could look into social equity, poverty reduction, other social needs and identify solutions that are adaptable to local conditions with inputs from foreign collaborators where necessary.

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Scientific Research in a Developing Nation

Dr Geethika Yapa

Scientific research is the systematic investigation of scientific theories and hypotheses and thus forms the foundation of knowledge. Knowledge is a vital determinant of economic growth. Knowledge is what the society creates, communicates and uses for the well being of the people. Scientific research is the major driver of social and technological innovation that can lead to national development through knowledge to action process. Skilled human resources, levels of national technological adaptation capacities as well as information and communication (ICT) facilities have a positive effect on economic growth of a country.

Developing countries with comparatively small economies, a higher population, acute poverty rates and limited technical capacity to conduct, adapt and apply scientific research are the most vulnerable to lapses of new knowledge generated through Research and Development. Significant challenges are encountered when conducting research in developing countries. Inadequate funding, limited and weak infrastructure, inadequate support services, stringent and rigid procurement procedures and red tape are some debilities which hinder the progress of research. Further, lack of appropriate policies and state patronage are also constraints encountered by scientists in developing countries.

Promoting Science and Technology and harnessing its end products are essential requirements for a country's economic development. An example is how investments in research, development and innovation have transformed Singapore from a developing nation to a thriving developed country within a span of 50 years. Through the implementation of five timely National Science and Technology plans, Singapore is now positioned as an innovation driven, knowledge based economy, with a public R & D budget of $ 19 billion for 2016 –2020.

Korea and Taiwan are two more countries that have emerged from poverty to industrialized nations through the promotion of Science and Technology. Korea initiated activities through its first economic

NSF Award Ceremony - 2018

development plan in 1962, and at present has a strong economy which is mainly propelled by science and technology. According to statistics from the Asian region (www.rdmag.com), India, South Korea, Japan and China collectively account for nearly 44% of the global R & D investment with China contributing 21.68%. In 2014, the Republic of Korea had a contribution of 4.23 (Gross Expenditure on R&D (GERD) as a percentage of Gross Domestic Product (GDP) while Singapore had 2.02 and China 2.07. All these countries now are developed nations with strong economies achieved by advancing science and technology. Though a developed country, India's contribution to R & D has been comparatively small with only 0.62% of the GDP being infused into Science & Technology.

When the status of Sri Lanka is considered, a decline in the total investment for R & D is seen,which ranges from 0.3% in 1966 to 0.11% in the year 2013.

The highest investment had been in 1974 when 0.4% of the GDP had been allocated to R & D. From 2013 to 2015, there had been no increase in funds for research, raising concerns among the scientific community on the low priority given by the state to Science and Technology.

Further, a mere 292 researchers (head count) and 106 (full-time equivalent) researchers per one million population made up our country's research base in 2015, whereas the actual need of skilled researchers for the development of Sri Lanka is far more. In the year 2015, only 944 qualified with PhDs, 266 with MPhil qualification, 640 qualified MD/MSs and 609 with MSc qualification (Full time) constituted our research population.

National Science Foundation (NSF) and its predecessors being the premier state institutions for promoting Science and Technology in Sri Lanka, have facilitated R & D activities of Sri Lankan scientists since 1970. NSF which was the successor of the Natural Resources Energy and Science Authority (1982) and the National Science Council (1968) incorporated in 1998 through the S& T Development Act of 1994 is mandated to serve and strengthen the Science and Technology sectors in Sri Lanka. It has taken the lead in mobilizing and leveraging science to pave the way for a knowledge-based economy.

During the long journey spanning 50 years, NSF and its predecessors have established many vital and important mechanisms to strengthen the national R & D base. Many scientists currently at the pinnacle of their careers as well as budding and young research personnel, have got their research careers off the ground by securing their very first research grant from NSF and the two predecessors. NSF has a wide array of activities and Grant schemes which promote capacity building of scientists in all areas of S & T, development of research infrastructure, funding for technology transfer, knowledge creation and sharing, fostering international collaborations and science popularization to pave the way for economic success, and thereby, improve the quality of life of the people.

Through the longest standing research support scheme, the Competitive Research Grant Scheme over 2600 research grants have been awarded to date. An important output from these grants has been the training of young and budding scientists at postgraduate level, facilitating them to acquire PhDs and MPhils, thereby fulfilling one of the main needs of the country in order to move towards a knowledge-based economy.

Further, research papers written in local and international journals as well as research communications have strengthened the knowledge-base with novel findings.

Even though the Treasury allocation for scientific research has decreased in the last decade, the annual scientific publications have progressively increased indicating the high quality and acceptance of research findings of Sri Lankan Scientists.

The National Thematic Research Programme (NTRP) initiated in 2010, is a mission oriented, multidisciplinary collaborative research programme which addresses national research priorities. These contract Research Grants are expected to provide holistic and inclusive solutions to address the research problem. Under this scheme, the first theme on Food Security, has been successfully completed and yielded results with some of it already being implemented by the State. Scientific investigations on two other themes, Water Security and Climate Change (CC) and Natural Disasters (ND) are now ongoing themes. The CC and ND themes have been developed on the expectation of achieving

Sustainable Development Goal : 13, which requires urgent action to combat climate change and its impacts. Through the grants awarded under this theme, it is expected that in Sri Lanka, the main targets under this Goal (13.1, 13.2, and 13.3) will be achieved. The NTRP on Water Security is in line with the SDG-6, taking into consideration local, regional and global issues in the water sector.

Yet another research support scheme which promotes postgraduate research is the Research Scholarship Grant Scheme of the NSF initiated in 2004. During the period 2008 – 2017, 58 awards have been made under this scheme to support research leading to PhD and MPhil degrees for outstanding, young graduates and engineers. Further, the post doctoral research scientist grant scheme is an attraction for fresh Sri Lankan PhD holders to conduct post-doctoral research locally. These 03 grant schemes contribute significantly to the development of a strong scientific human resource base in the country.

If Sri Lanka is to keep up with the global developments, it is imperative that a critical mass of trained and skilled R & D personnel are nurtured continuously. NSF, in keeping with this requirement, initiated the Support Scheme for Supervision of Research Degrees in 2011 to motivate, support and recognize the senior scientists/ engineers engaged in supervising postgraduate students conducting research in all areas of Science and Technology. This scheme also encourages Universities and research institutions to promote and facilitate postgraduate research training. From 2012 to 2017, through this award scheme, 218 supervisory teams have been rewarded.

A key limitation encountered by R&D personnel is the high cost of current scientific literature. The cost of subscriptions of databases and journals are beyond the reach of both individual scientists and most science libraries. The National Science Library and Resource Centre of NSF has stepped into bridge this gap and provides an efficient information dissemination service to the scientific community and access to updated literature including databases.

The Journal of the National Science Foundation is the only scientific journal in Sri Lanka, listed in the Science Citation Index of the Clarivate Analytics. Through this Journal, NSF has opened up a channel for our scientists to disseminate their research outputs to a global audience. The second Journal nurtured by the NSF, the Sri Lanka Journal of Social Science publishes social science research conducted by our researchers. During the last three years, 81 JNSF and 29 SLJSS full research papers have been published, thus facilitating knowledge sharing and dissemination.

The commitment and effort by NSF to strengthen the research infrastructure in Sri Lanka is evident by the investment of Rs 213 Million in 145 Research Equipment Grants awarded to Universities and Research Institutions during the period 2005 – 2017. Out of the 64 Grants awarded during the 5 year period from 2013 to 2017, 39 have been used to conduct research activities funded by NSF while 289 projects funded by other sources have reaped the benefits of this facility. In mid 2000, recognizing the crucial role played by R & D in advancing socio economic development, NSF spearheaded the National Nanotechnology Initiative, which culminated in setting up of the Sri Lanka Institute of Nanotechnology (SLINTEc) in 2008. This is now the foremost institution in Sri Lanka for cutting edge nanotechnology research. The setting up of a Nanotechnology Park in Sri Lanka has also been initiated. NSF also initiated several other grant schemes including support for technology development and to begin businesses based on novel technologies to propel industry–oriented research.

International Travel Grants, Overseas Training Programmes, Funding for S & T Publications, supporting page charges of research papers published in indexed journals are some other much sought–after facilities that NSF offers to our scientists who attempt to excel in their research efforts.

Focusing on strengthened bilateral scientific cooperation and harnessing the benefits of same for the development of the country, NSF initiated bilateral collaborative research programmes with the Pakistan Science Foundation, German Research Foundation (DFG) and DAAD (The German Acadamic Exchange Service) of Germany, Japan Science and Technology Agency (JST) and National Natural Science Foundation of China NSFC) with more to come. It is expected that

Workshop on Research Management, 2017

these joint research programmes which include exchange of researchers, will enhance the research skills and expertise of our research community to serve the nation better.

From its humble beginning as National Science Council in 1968, NSF has developed into a fully fledged funding authority, through the vision and leadership provided by successive Boards of Managements. It plays a pivotal role in national development.

NSF has qualified and committed staff to carry out the mandated activities. With this backdrop and the firm support of the government by investing sufficient funds, the granting of R & D tax incentives, the permitting of flexible but transparent procurement methods and the willingness of our scientists to forge ahead despite impediments, Sri Lanka can look forward optimistically to a knowledge–based, strong economy in the foreseeable future.

NSF Research Summit - 2016

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STEPS IN CONDUCTING A RESEARCH PROJECT

Step 1: Identify the Problem
The first step in the process is to identify a problem or develop the research question. The research problem may be something identified as a problem, some knowledge or information that is needed by an organization.

Step 2: Review the Literature
The researcher must learn more about the topic under investigation. To do this, the researcher must review the literature related to the research question. This should cover local and global literature including recent research activities. This step provides knowledge about the problem area. The review of literature also educates the researcher about what studies have been conducted in the past, how these studies were conducted, and the conclusions in the problem area.

Step 3: Clarify the Problem
Once the literature review has been completed, researcher may expand/narrow down the scope of the research project.

Step 4: Define the objectives and hypotheses
Define the general & specific objectives. Objectives are the broad statements of desired outcomes. They should be clear and summarize what is to be achieved from the project.

Step 5: Methodology
This is a very crucial & important part of the research project, which will decide the success or failure of the research project. Methodology has to be very precise and accurate and should be aligned to achieve the proposed objectives.
For research projects involving human subjects/animal models it is mandatory to obtain ethical clearance from the relevant institution.

Step 6: Results and Discussion
The collected data has to be analyzed through appropriate and relevant tools (including statistical methods) to yield the expected outputs. The results have to be carefully interpreted to formulate the discussion. The negative results obtained, if any should also be discussed here.

Step 7: Conclusions
It is very important to give clear conclusions based on the results obtained. Further research needed stemming, from the research project can also be included in this section.

Step 8:List of References
References that are used for the research study should be listed.

Science for Evidence Based National Policies

Dr P.R.M.P. Dilrukshi

What is a policy?

A policy is a set of ideas or a plan of what has to be done in a particular situation that has been agreed upon officially by a group of people, a business organization, a government, or a political party. A policy includes a deliberate system of principles to guide decisions and achieve rational outcomes. Therefore, a policy is a statement of intent and is implemented as a procedure or protocol. Policies are generally adopted by a governance body within an organization or a country.

Public policy consists of three major types

1. Regulatory policy
2. Distributive policy
3. Redistributive policy

Each type of policy mentioned above has its own special purpose. A major goal of regulatory policy is to maintain order and prohibit behaviour that endangers society. The voting policy of Sri Lanka, the traffic ordinance et al are examples that come under regulatory policy. The distributive policies usually are implemented to encourage people to do certain activities. These include granting of tax concessions for industries in order to encourage them to do more research and development work.

The focus of redistributive policies is on granting certain benefits to the community, group or company in order to encourage certain activities such as giving fertilizer subsidiary for Sri Lankan farmers.

What does the policy formulation process involve?

1. The identification of the policy issue 2. The formulation of a policy to address the issue 3. The adoption of the formulated policy 4. The implementation of the policy adopted 5. The evaluation of the policy after the implementation to assess whether it has addressed the issue 5. If it has not functioned as desired, the termination of the implemented policy.

In order to identify a problem which needs policy intervention or to formulate a policy, it is necessary to possess correct information which is called evidence. To find correct evidence it is necessary to conduct comprehensive research that gives evidence to correctly identify the policy issue and come up with reliable policies to address the issue under discussion.

Thus, the National Science Foundation has established a Science and Technology Policy Research Division (STPRD) to conduct policy research in the areas of Science and Technology. This functions with the intention to give policy recommendations and indictors to support policy planners and authorities who are involved in policy formulation in the areas of science and Technology.

Science and Technology Policy Research Division (STPRD)

The Science and Technology Policy Research Division (STPRD) was established by NSF in January 2005. This was set up with a view to establish a research arm in the areas of Science & Technology. As such, evidence based research data could be provided through the development of Science & Technology indicators. Its mission is to provide information on Science, Technology and Innovation (STI), education and other related fields to the policymakers and others nationwide. Also, to make the society aware of the important issues relevant to Science & Technology towards the economic development of the country and the general welfare of the society.

Fig.01 : Statistical handbooks published by NSF

The main focus of the STPRD has been made in the following directions;
The undertaking of Science, Technical and Innovation policy research in areas of importance in order to make recommendations towards policy formulation.
The development of databases relevant to all sectors of STI which will be found useful in decision making.

The undertaking of public awareness programmes and discourses on nationally important issues related to the areas of Science, Technical and Innovation.
Investigating, collecting, reviewing and consolidating Indigenous Knowledge (IK) that exists and practiced in Sri Lanka.
The undertaking of capacity building of human resources especially in the areas of Social Sciences and Indigenous Knowledge.

Science, Technology and Innovation (STI) policy research

National Research Development and Innovation (RDI) Survey Science and Technology Policy Research Division (STPRD) has been conducting a regular Research Development and Innovation Survey once in two years since 2004. From 2013, the survey has been conducted every year. It measures and reports the status of Science, Technical and Innovation in the country in terms of investment on Research, Development and Innovation, the engagement of Human Resources in the STI and the output of the Science, Technical and Innovation sector in spheres of publications, patents, technologies, innovations et al. The indicators generated in these surveys are useful for STI policy formulation, to address policy issues and gaps in the country. The policy recommendations that arise from these surveys provide insights to create an effective and productive RDI system in the country. The information provided in the handbook is used by policy planners, administrators such as those in Ministries of Science & Technology, Ministry of Finance, Central Bank, Department of Planning et al. The NSF also acts as the focal point in providing information to the United Nation Institute of Statistics to compile the Global report on Science, Technical and Innovation.

Tracer Study of Graduates and Postgraduates

The Science and Technology Policy Research Division of the NSF conducted several studies to measure the employability of Science & Technology graduates and Postgraduates who passed out from the national universities. These Tracer studies have been used as a tool to examine the level of Science & Technology manpower required in the labour market at graduate level and to forecast demand and supply in the coming years. This in turn facilitates policy changes in relation to effective utilization of Science & Technology manpower.

National Innovation System (NIS) Studies

A national innovation system can be perceived as a historically grown subsystem of the national economy where various organizations and institutions interact and influence each other in carrying out innovative activities. Thus, Science and Technology Policy Research Division (STPRD) focuses on carrying out regular NIS activities to provide the necessary policy incentives towards the development of the Innovation system in the country. NSF's main focus is on small and medium scale industries in the country that have great potential for development and expansion.

Study of factors affecting research on social science

A survey to investigate the factors affecting research on social science in Sri Lanka commenced

in 2016. This survey was designed to investigate the cause of the poor quality and the low number of research studies in areas of social sciences and humanities. The recommendations based on the findings of the survey will be utilized to develop programmes to uplift research on social science in the country and thereby ensure the creation of a research culture beneficial for formulation of national development policies.

Collecting, Collating and Dissemination of Scientific information towards Policy Formulation and Research

Science and Technology Policy Research Division (STPRD) is developing and maintaining several databases.

Science and Technology Management Information System (STMIS)

The demand for information related to the capabilities in the various fields of the Science & Technology sector evolved due to the need for the application of knowledge in Science, Technology and Innovation in the economic development of the country. And also for the identification of indicators and pointers to develop policies. In order to face these challenges, information related to the Science & Technology sector

Fig.02 : Science & Technology information management system

Fig.03 : Establishment of YSSF

was collected and collated in a systematic manner. And these were arranged in a more integrated form in order to link the capabilities of the Science & Technology personnel with other functions. These functions include services, training, research, development and infrastructure facilities in the Science and Technology Management Information System that has been established and maintained by the STPRD since 2004.

Directory on Social Scientists

Science and Technology Policy Research Division (STPRD) has launched a project to compile a Directory of Social Scientists in Sri Lanka.

The establishment of the Young Social Scientists Forum (YSSF)

NSF has undertaken an initiative to establish a Young Social Scientists Forum (YSSF) to provide a common platform for young Social Scientists to discuss and take initiatives to improve their performance besides taking part in national development activities. The forum will act as an incubator which provides the opportunity to develop research-ideas to fruitful research projects under

Fig.04 : Collection & Validation of indigenous knowledge

the guidance of renowned senior scientists in the country.

The establishment of the Senior Social Scientists Forum (SSSF)

A Senior Social Scientists Forum (SSSF) has also been established at the NSF in order to get the active contribution and participation of senior social scientists in the research and programmes conducted by the NSF and also for the activities pertaining to the national Socio-economic development.

National Expatriate Scientists Database

A database has been developed on expatriate scientists who worked in different countries in the world and engaged in activities related to Science and Technology. The main objective of this is to obtain their contribution and collaboration towards national programmes.

Collection, Validation and Protection of indigenous knowledge (IK) which subsists in Sri Lanka

The sustainable development of a country should be closely linked with the conservation and sustainable utilization of biodiversity, making use of components of indigenous knowledge and practice of the country. Indigenous knowledge systems of the people of the world constitute a reservoir of knowledge of diverse areas that include a sound practical knowledge linked with the sustainable use of plant, animal, life on earth and beyond. Recognizing the importance of this, the Scientific Advisory Board to the Secretary-General of the United Nation decided at its third session in May 2015, to prepare a policy brief for the attention of the Secretary-General indicating the important role of Indigenous Knowledge for sustainable development and providing recommendations for enhancing the synergies of IK and Science (UNESCO Science Report, 2015). Accordingly, the NSF Working Committee on Indigenous Knowledge works toward identifying, collecting and protecting of indigenous knowledge that had evolved and utilized over the last several millennium in Sri Lanka.

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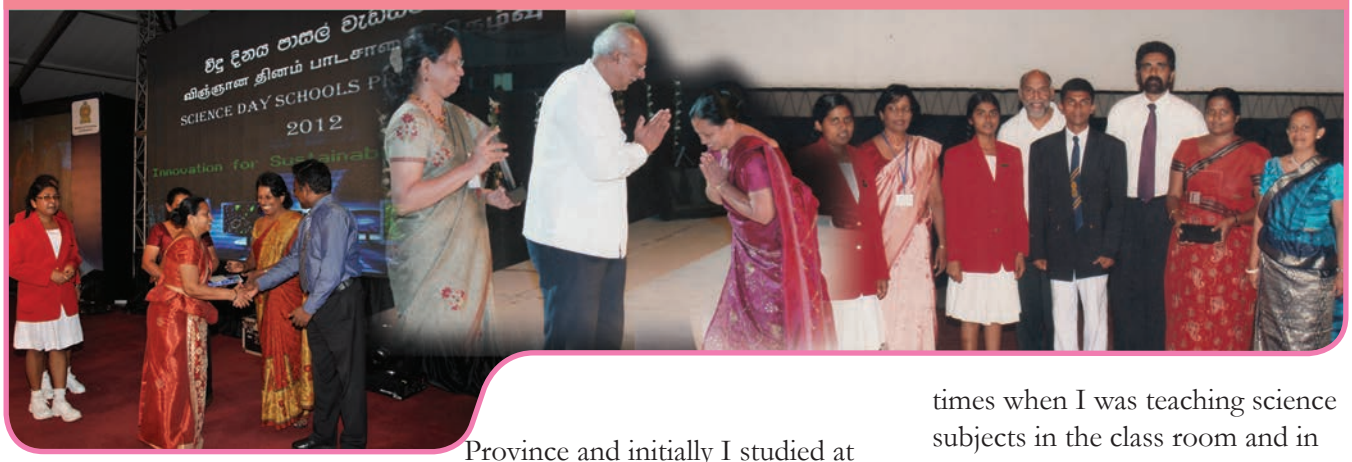
The Secret of Becoming a Successful Science Teacher

Rekha Guruge



Science is a practical and an interlectual process which conducts observations and investigations of the structure and behavior of the physical and natural world. You would understand that this definition is not the ideal explanation of science. You may have your own specific definition of science. If so what is the definition that you can give for the term "science teacher" I will not hasten to ask that question from you. This is he cause I have a story to relate.

I was born in the Southern Province and initially I studied at Baddegama Christ Church Devi Balika Vidyalaya. Then I stepped into the educational field as a novice science teacher. Then I studied as a student of the first batch of Siyane Educational Science Faculty. This was something I was dreaming of. It was when I was in the Central Province that I learned the foundations in science teaching as a practical science teacher. During an era when student centerd educational system was being introduced. I must state here that one question that arose in my mind innumerable times when I was teaching science subjects in the class room and in the laboratory, was that is it only in the class room and the laboratory that the scientific concepts be established well and truly in the minds of students? And in answer to my question I realized that in order to enlighten the students the National Science Foundation (NSF) implements different kinds of teaching programmes. From that day I felt enlightened. NSF has shown that through drama and acting it is possible to instill in the minds of students the scientific concepts which are otherwise not easy to teach.

World Science Day - 2013

At that time I was a teacher at Matale Sri Sangamiththa Girls School. I was in charge of the science association and I together with the teachers of science and aesthetic studies produced science oriented dramas. The dramas that were produced on various themes such as the power crisis, innovations for sustainable development and climate change were presented at the World Science Day, and won prizes. Without stopping at that, we got an opportunity to show these dramas to the other children of the country

over the National Television. This was done with the cooporation of the NSF and National Television. It was quite obvious that it is possible to instill in an indelible manner the scientific concepts through science oriented dramas. I realied that through these dramas I have been able to achieved something more successful as a science teacher in the classroom.

Science oriented drama production was not the only opportunity provided to me by the NSF a science teacher, as NSF had also launched programmes involving *viridu*, oratory, posters, digital narrations, role acting as well as science research projects. When these were presented by students, and when they won certificates, received credits or won medals, the students were overjoyed. I experienced immense pleasure by carrying out these programmes. Even children who were not very fond of science subjects began to like these subjects, and were motivated to produce such programmes. These undoubtedly helped to bring about a change in the teaching methods that I has been practicing so far. When I saw their enthusiasm, I realized that NSF had launched a valuable programme to popularize science.

All though physics, chemistry and biology are considered separately they are the various component disciplines that have to be taught under the subject of science. We are aware that various investigations have been carried out, and continue to be carried out. The student who is presently studyng in the class room today may in the near future be looking for a solution to an environmental problem or introducing a new invention, or inventing an environmentally friendly machine as a solution to the power crisis, or introducing a new pesticide. It is the science research project programmes introduced by NSF that provided the answers to the question raised by me and many other science teachers on how a science student in the classroom could be motivated towards innovations in science.

Another activity that I very fondly directed the children was the science project competition, where children in groups or as individuals participated in various research activities that were even beyond my expectations. This was a collective activity which involved all science teachers, and providing opportunities for many children to participate. The students of our school were able to reach even international levels soley due to the encouragement provided by the NSF.

Another great achievement to our school was the development of a plant extract based insect repellent which was effective to repel cockroaches. This winning group project enabled all students who conducted the project to participate in the Intel International Science and Engineering exhibition that was held in the United State of America. This was an achievement for the school. Another student successfully conducted a science

research project to find a suitable colour trap to control the pests causing chilly leaf curl. A a result of this achievement, I got an opportunity to accompany her for participation in the Taiwan International Science Exhibition in 2012. Our participation was entirely sponsored by NSF. On this occasion she represented Sri Lanka and was placed in the 4th position which gave me emense pleasure to witness her receiving the certificates and the cash award. I had never experienced such pleasure before being very fortunate to have worked with the NSF in order to make a comparative analysis of the science education in Sri Lanka and another country.

Another unique programme of the NSF is persuading the school children to study the scientists of their liking and produce dramas portraying them to highlight that students themselves have the potential to become scientists. As a teacher I had not thought of this aspect before. However I saw the pleasure, and enthusiasm they displayed in collecting such information and talking about scientitists, and their willingness to carryout investigations through this activity.

The School Principal and staff of Sri Sangamiththa National Girls School were thrilled when the schools Science Society won the highest Five-Star award granted by NSF. All these achievements were possible becomes of the co-operation extended by everyone in discussing, analyzing and coming to conclusions.

I am happy humbly to state that in this matter I followed the traditions set by NSF. I value the co-ordination ability, competence and the friendliness of this institution. It gave me great pleasure to receive the competency certificate awarded to a teacher in the year 2008 for promoting science among school children under NSF merit awards scheme. It made me very happy when in the year 2010 I received the National Award for teachers for promoting science among school children.Since this is a once in a lifetime award for a teacher, I consider this opportunity as a unique event.

While being engaged with all these extra curricular activities, I am happy to have been able to conduct my teaching activities, and duly complete the syllabus. In appreciation of this achievement, I was presented with certificates for enhancing the GCE O/L science results at the Matale Regional Science Day.

As a result of being enriched and strengthened physically and interlectually in 2011, I organized a series of competitions for a Science Day with the co-operation of science teachers of Sri Sangamiththa Girls National School. These competitions incuded items such as dramas, *viridu*, posters, composing songs, character acting, knowledge assessment and composing science fiction the winners were awarded gold, silver and bronze medals and certificates. Simultaneously a science journal was launched. The theme of the Science Day was "Towards a Green World through scientific wisdom".

"විද්‍යාවෙන් දැනුම ලබා
දහමින් විදුනැණ පාදා
නව නිපැයුම් ලොවට තනන
නව තෝතැන්නක්
විදු දින විදු නැණ වඩනා
නව තෝතැන්නකි"

The above is a part of the theme song. I recall this Science Day event with extreme happiness. The visit by the learned scientists from the NSF to our school, who accepted. Our invitation to participate on that day made everybody happy

specially considering the fact that our school is located in a far away place from Colombo.

The visit by scientists of NSF, who humbly accepted our invitation to participate in the event, and travelled all the way from Colombo, gave us encouragement and strength. I recall with much respect the presentation regarding the activities of NSF, which was of great value to the teachers and the students. There were teachers and students representing other schools in Matale who participated in this science day. The guest who was invited to deliver the main speech was also a Sri Lankan scientist selected by NSF. The speech delivered contained very valuable information for all of us. We thank NSF with affection and devotion for the continued encouragement of the students as well as the teachers. NSF serves the nations' children like the shadow of a huge Banyan tree providing shade to all.

In restrospect there is something that I must say without any reservations. As a science teacher I was not restricted to the classroom or to the laboratory. I took the science students out of the confines of the classroom to the outer environment. There I truly directed them to activities.

Through these I gained experience to teach them practically to carry out investigations, and show them what their role should be in the modern world. I very humbly say that all these made me become a successful teacher. There is a voice within me saying, that the secret lies not only in my own efforts. It is also NSF which planted the seed of the tree of success initially, watered it, tended it and providing the necessary protection. It is important to acknowledge NSF for this effort. I do not hesitate to proclaim to the world that NSF was the secret of my becoming a successful teacher.

In order to make a chain, its links should be firmly welded. I feel that the NSF is doing this welding. It has assembled the teachers and students of a large network of schools at the zonal and regional levels to one location and uniquely propelled them to the stage to display their skills and competence at the national level. NSF has generated enthusiasm for science subjects among the students and unified them with the modern scientific world. Thereby it has facilitated Sri Lankan teachers and students to reach other continents in this field. But NSF has not stopped there. It also powered the way for Sri Lanka to place its mark in the world scene of science. It has helped to polish up the role of teachers like us. NSF our dear brother, thank you very much for all that you are doing for the teachers and students of science, and for the upliftment of science in Sri Lanka.

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National Science Library and Resources Center Assures Global S&T Literacy

Manuja Karunaratne

National Science Foundation (NSF) is the focal point for sharing information on Science and Technology in Sri Lanka. The communication of Science and Technology paves the way for the dissemination of scientific knowledge to the general public. In our country numerous ways are available to take knowledge of science to the people. In order to share knowledge, information is circulated through many kinds of printed media, such as via periodicals, textbooks, journals, newspapers and monographs. Some of the popular techniques of communication of science applied today include the organization of "Science Days" for school children, science exhibitions, workshops and seminars on science which enable the enhancement of knowledge among the Scientific Community. In addition, NSF's National Science Library and Resource Center can be made use of by the general public to gain knowledge on science by accessing its various online services and physical materials on science and technology.

The provision of information on science, technology and infrastructure on social, political, economic and natural development of the country are some of the foremost objectives of the NSF.

Sri Lanka Scientific and Technology Information Center (SLSTIC) which provides service and assistance to the National Science Foundation, was established in 1970, thus becoming the first science and technology publication repository in the country. This contains locally published and unpublished science documentations, articles published in magazines throughout the world, conference papers, research information, monographs, research papers and technical reports. The National Science Library and Resource Center strives to achieve these objectives by providing a 24 hour science based information service to the general public to help find literature on S&T through literature searches, awareness programmes, supplying of documents and training library professionals.

NSLRC depicts importance of S&T

National Science Library and Resources Center (NSLRC)is the premier focal point for the exchange and sharing of science and technology information in the country. A key objective of NSLRC is the exchanging of information among scientists in Sri Lanka and other countries and expanding and strengthening of the information network. In addition, it transfers information and communication technology to the science community which includes school children, university students, researchers and science academics – functions which rate as important services of the NSLRC. Sharing of such information relevant to science and technology with people may ultimately provide the basis for economic development of the country.

Recognizing the importance in the enhancing of knowledge in relation to educational and professionalism in S&T resulted in the setting up of the SLSTINET. Its objective is to broaden scientific and technological knowledge of library related professionals, researchers, academics and scientists. Its services include the introduction of library software giving support services for data entering, hosting of library databased training programs and arranging of

NSLRC Onsite services

seminars. SLISTINET currently provides its services to 119 libraries. And to benefit from such services, research, science, technology and non technical institutes have enrolled as members of the SLSTINET.

Other than these services, NSLRC is in the possession of a large collection of local and international research publications, technical reports, publications on science policy, reports on innovations which deal with new concepts and creations as well as a collection of periodicals, local and international electronic magazines and conference papers.

Besides, its large collection of NSF funded research reports, the series of NSF Monographs, Vidurava publications, past volumes of Sri Lanka Journal of Social Science and Journals of the NSF disseminate scientific information among the science community. Even to refer these locally published scientific publications from the NSLRC you can access the digital repository on www.dl.nsf.ac.lk

NSLRC website serves as a central gateway

NSLRC web page is a significant information sharing center on local and international scientific publications. It works as a hub for scientific information and aims easy access for scientific information followers from school to research level. The scientific community besides can access articles in local magazines and publications by clicking nslrc.nsf.gov.lk/new

Digital library for easy online access

In order to improve knowledge of S&T in all who seek its knowledge, NSF identified the importance of a national repository network of digitized information which stores articles and publications of relevance to the Scientific and Technology institutions. Towards this objective, in 2009, the first digital repository was established to store science publications of local scientists for circulation, data protection with open access to enable sharing within the scientific community. The National Digitization Project (NDP) program of the NSF was initiated in 2011 to digitize literature of local Science and Technology currently available in research and academic libraries in the country. The full texts of these could be accessed online easily and fast on National Network of Institutional Repositories operated across academic, research and related institutes. Therefore, the NDP paved the way to open doors to support and promote productive research and innovation in order to contribute to the social and economic development in Sri Lanka. Further, NSF provides on site hosting facilities for other libraries which request further assistance to develop digital repositories. The Digital Repository is run through the DSpace software and currently it contains 5,500 full text articles for reviewing purpose through the dl.nsf.ac.lk web page.

Vital services of NSLRC through local databases
Sri Lanka Science Index (SLSID)

Science community has now the capacity to acquire more knowledge by referring SLSID which is a monopolized storage of reviewed local researchers. It contains more than 40,000 science and technology researched articles. Reviewers can refer these as complete texts of articles or, if necessary, purchase through the internet articles of any journal, conference papers, research reports, technical reports, researches, and unpublished articles. Sri Lanka Association for the Advancement of Science (SLAAS) NSLRC subscribed to SLAAS with the aim of sharing information on progress of science as given in SLAAS annual reports. It has maintained 8,367 published papers from 1976 to 2016.

Research Grant Database (RGRA)

NSF provides payment to enhance the capability to do new research and maintain productivity. RGRA maintains 2,110 summarized information of research projects of the National Science Foundation and research of University graduates. More information can be obtained by visiting http://www.viduketha.nsf.ac.lk

Sri Lanka Journal Online (SLJOL)

SLJOL has information on science published in local journals which can be obtained online. It has 1,005 issues of 75 Sri Lankan scholarly

journals with 9,056 articles in the areas of Agriculture, Engineering, Medicine and Social Science as well as analysis of information. The online platform offers the provision of practical and technical solutions to those who lack information. These in digital format, are available in full text as published in journals. Workshops and training sessions besides are conducted to motivate editors of local journals. Those interested can visit SLJOL through its web page: http://www.sljol.info web page.

NSLRC sleeves up International Science and Technology SCOUPUS Abstract & Citation Database

NSLRC has subscribed to Scopus which provides solutions to global scientific studies through the most efficient knowledge/ Information analysis tools. This is in order to assist researchers, to help track products in institutions which cover more than 27 million patent records, e-prints, thesis, dissertations and websites. The service covers 360 trade publications, over 530 on-line book series and over 7.2 million conference papers. Being an international database, it offers access to over 21,500 peer reviewed journals from over 5,000 publishers. Scopus is a fast, user-friendly and comprehensive on-line database that supports research needs in the field of Science, Technology, Medicine, Social Science, Arts and Humanities. Details of these are available on https://www.scopus.com

The Essential Electronic Agricultural Library (TEEAL)

TEEAL provides excellent information in the field of agriculture which contained in 425 agricultural journals published by prominent publishers and reviewers. This can be accessed through the http://teeal.nsf.ac.lk

NSLRC Digital library services

Health Inter Network Access to Research Initiatives (HINARI)

Hinari is a programme which has been set up to help access one of the world's largest collections of biomedical and health literature. It contains up to 13,500 journals in 45 languages and up to 60,000 e-books as well as 110 other information resources to health institutions in more than 115 countries, areas and territories which should benefit thousands of health workers and researchers, a facility that contribute to improve world's health.

Access to Global Online Research Information in Agriculture (AGORA)

In order to fill the vacuum in agricultural knowledge, AGORA shares digitized agricultural journals covering areas of food, agro, environmental science and related fields. This facility of AGORA covers 21000 journals.

Access to Research for Development and Innovation (ARDI)

This contains scholarly literature for free online access to scientists in diverse fields covering information of publications relating to science and technology in 10,000 journals and books.

The National Science Library shares information with scientists, undergraduates, students and the general public and the required information can be obtained through journals, photographs and the internet. NSLRC services are available from 8.30am – 4.15pm on working days. Enquiries can be made on the telephone number 0112696771-3 or by visiting www.nsf.ac.lk.

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Scientific Writing and Publishing : a Way of Communicating Knowledge

Dr S.A.V.Moorthy

Writing is the most important means of communicating scientific work. It is used to document and communicate ideas, research findings and new developments to others. There are Various forms of scientific writing such as research papers, articles, reviews, book chapters, research notes *et-al*., can be seen. Articles and research papers have to be published in academic journals or magazines for the purpose of recording and to get value for such information. Doing research is only part of the cycle, and the cycle will be completed when the findings of research are published. Researches doing so, gain recognition, appreciation and acknowledgement as experts in their expert fields at national and international levels. It also gives recognition to not only to an individual but also to the department and institution, and in some cases where the topic is globally important, the country of the author may also gain recognition.

It must recalled that Derek Solla de Price (1967) one of the outstanding and prolific writers on Philosophy, history of science and science policy in the mid 20th centry in one of his classical papers titled "Nation can publish or Perish" which later become a popular slogan.

Scientific writing and publishing

A scientific paper is "a written and published report describing original research results", according to Robert Day1. According to him, a scientific paper must be a valid publication, and it must be published in the right place. A Research article is a written form of an original study published in an academic journal. As such, it is a primary source of information. A scientific paper should be simple, clear, impartial, accurate, and structured logically. The way of writing and the language used, and the targeted readers are also to be considered when writing a scientific paper. Generally Technical jargon and lengthy words/sentences have to be avoided.

Scientific research articles provide a method for scientists to communicate with other scientists about the results of their research findings. Generally a standard format which includes title, authors name and affiliation, introduction, materials and methods, results, discussion, acknowledgement, and references, is used in writing scientific articles, in which the results are presented in an orderly and logical manner. More attention is given to publications by academic institutions in recent years.

Publishing research results/findings has an impact on the development and growth of science. If results and ideas are kept secret science will not progress. Publishing will result in contribution to knowledge creation, and in addition, receive constructive criticism, which may help other researchers to do further research in that area, and for policy makers to develop evidence based policies. As well as to take decisions while appreciating and valuing the evidence generated. This in turn will contribute to the socio-economic development of the country and improve the well-being of the people.

What is the necessity to publish?

Publishing research findings is crucial for a career of an academic. This can result in enhancing credibility of a scientist/researcher, and will help to established

new scientific collaborations or consultancy, while keeping the authors updated with the latest research. Further, publications also yield indirect rewards. For example, it will help to improve a researcher's job prospects, as well as the ability to be promoted. Considering the following benefits in publishing scientific articles, scientists/ researchers are encouraged to write and publish their results.

Reasons for publishing

- To let others know that something has been discovered
- To disseminate results in the most prestigious and productive way
- To exchange ideas
- To add to the body of knowledge
- To get academic recognition and career enhancement
- To build a stronger personal brand
- To get refined in communicating and writing skills
- To learn from constructive feedback provided by reviewers
- To establish valuable collaborations
- To develop or improve on existing policy
- To gain personal satisfaction and confidence
- To show funding agencies that work has been done

Fig.01 : Journal of the National Science Foundation (JNSF)

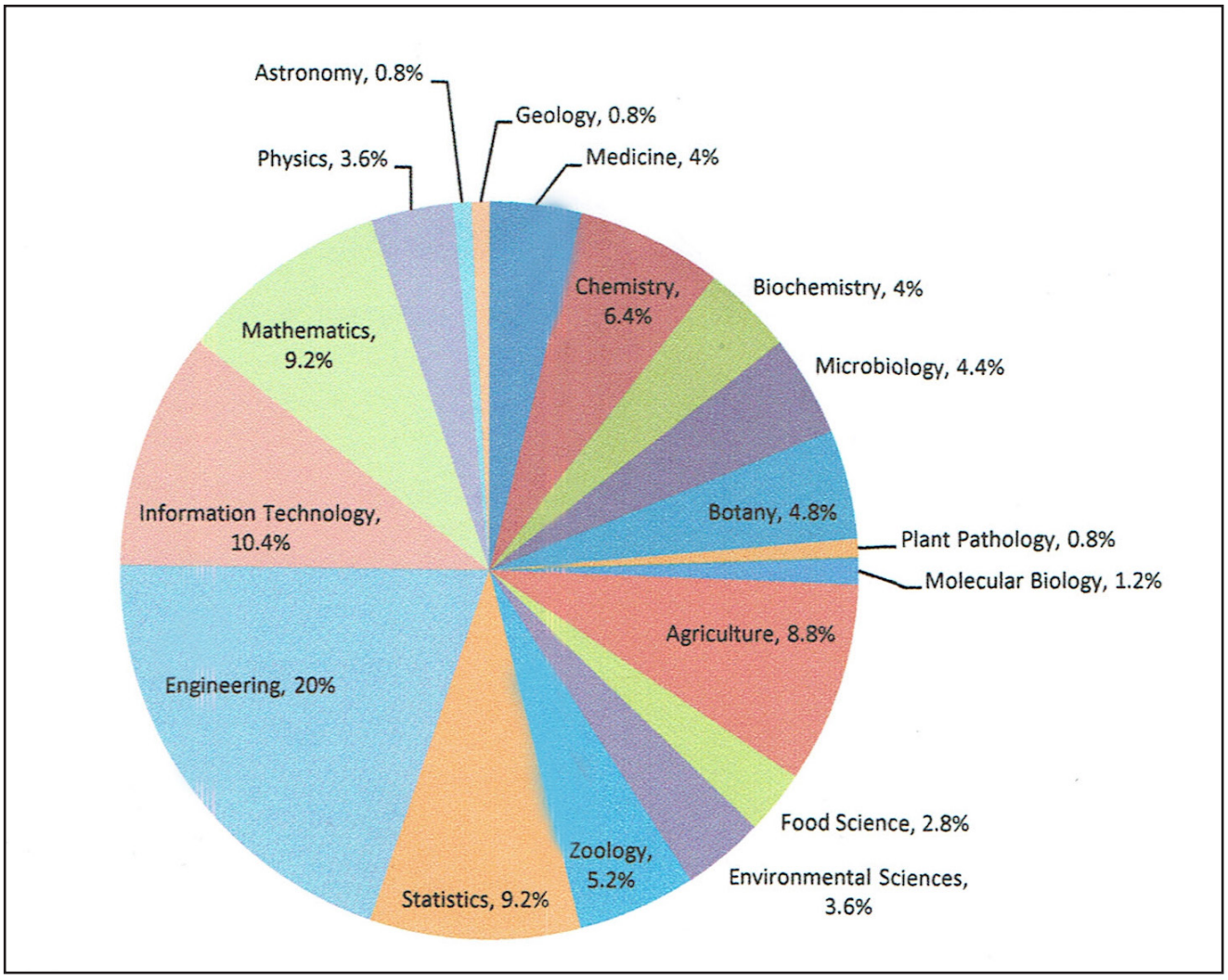

Fig.02 : Submissions of articles to the JNSF by different disciplines

Role of a scientific journal

Researchers publish and disseminate their work in different ways: publications in books, journals, conference proceedings etc. Publishing in different formats differ across disciplines. Academic journals first appeared in the middle of the 17th century2. Their importance as a means of disseminating knowledge has grown considerably since then. Journals have to play an important role in disseminating accurate information to the community. It is imperative for a scientific journal to get international recognition by publishing high-quality articles. Editors and Reviewers play major roles in these tasks.

In academic publishing, a scientific journal is a periodical publication intended to further the progress of science, usually by reporting new research finding. Scientific journals serve as permanent and transparent forums for presentation, scrutiny, and discussion of scientific investigations. Publications in these journals are usually peer-reviewed. There are thousands of scientific journals. Some are peer-reviewed while someother journals are indexed and peer-reviewed. Some journals are not peer-reviewed.

Peer-reviewed and Indexed journals

Peer-review is the review of articles by one or more experts of similar competence to the authors (peers) before it is published in the journal to ensure the quality, scientific validity, accuracy and suitability for publication.

Fig.03 : Sri Lanka Journal of Social Sciences (SLJSS)

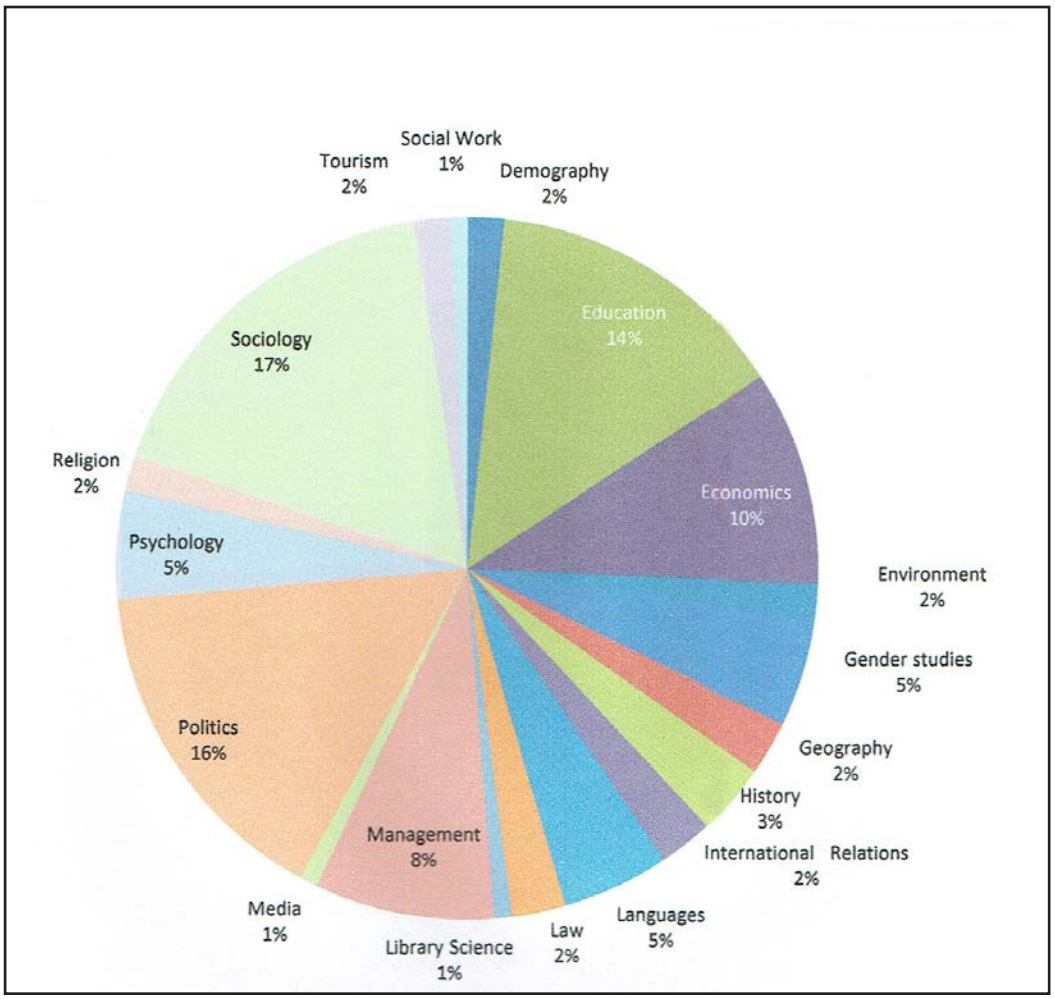

Fig.04 : Submission of article to the SLISS by different disciplines

A common rating system for journals is "indexing". An indexed journal is a journal included in leading databases such as Science Citation Index, SCOPUS, PubMed Hinari, Ulrich's International Periodical Directory, Index Copernicus, Pro Quest etc. The most commonly used index worldwide is science citation indexed (SCI) or social science citation index (SSCI) or engineering index (EI). Indexation of a journal reflects its quality. Indexed journals

are considered to be of higher scientific quality as compared to non-indexed journals. Indexing of journals increase their visibility, availability, and readership.

Impact Factor and Citation

Impact Factor (IF) of a scientific journal is a measure reflecting the yearly average number of citations to articles published in that journal. Impact Factor is commonly used to evaluate the relative importance of a journal within its field. IFs' are calculated yearly for journals listed in the Journal Citation Reports which is an annual publication by Clarivate Analytics (previously owned by Thomson Reuters). IF is not available for all indexed journals. Journals with higher impact factors are often deemed to be more important than those with lower ones.

Citation is a quotation from or reference to a paper, book or author. Citations will help to assess current trends, gaps and emerging fields of research. A citation index is an academic credit report which indicates how a researcher scores in the citation index in that particular field.

Open access

Open access means "availability to all". Recent developments in technology has enabled access, search, and share of published information increasingly with greater ease and speed. The technology has also made submission and review process and time for the publication easier. In open access, research outputs/ publications are freely available online to all at no cost. All forms of published materials such as peer-reviewed and non peer-reviewed journal articles, conference papers book chapters and monographs can be made open access.

Journals of the National Science Foundation

The National Science Foundation publishes two journals, the Journal of the National Science Foundation of Sri Lanka (JNSF) and the Sri Lanka Journal of Social Sciences (SLJSS), with the aim of promoting and assisting the publication of research results. Both are open access and peer-reviewed journals.

The JNSF has been publishing the results of research on all aspects of Science and Technology since 1973. It accepts research papers of both local and foreign researchers. The submissions to JNSF cover a wide range of disciplines in Science and Technology, predominantly with Engineering, Information Technology and Mathematics(Fig.01).Four issues of the journal are published per year in March, June, September and December. It is indexed in Clarivate Analytics and various other databases such as Chemical and Biological Abstracts, BIOSIS Previews, Zoological Records, SCOPUS, TEEAL, Ulrich's, AGRICOLA and EBSCOhost.

The Journal has a wide circulation both locally and overseas. Authors from over 25 countries have published their articles in JNSF. After getting indexed and being open access and peer-reviewed, the JNSF has observed an exponential growth in submissions. JNSF Impact Factor for 2016 is 0.42, which has increased significantly when compared to the previous year.

The Sri Lanka Journal of Social Sciences (SLJSS) is published twice a year in June and December. The journal publishes articles in Sinhala, Tamil and English languages covering the entire range of disciplines in Social Sciences, focusing on Sri Lanka and other South Asian countries since 1978. The journal covers a wide array of disciplines in Social Sciences and humanities predominantly in Sociology, Politics, Education and Economics.The journal is currently indexed in SCOPUS, and is in the process of getting indexed under Clarivate Analytics.
Finally, scientific writing and publishing serve as an essential tool to communicate scientific results and ideas among the scientific community that will contribute to the expansion of scientific knowledge, while giving personal satisfaction to the author.

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What have you learnt from the Vidurava 2018 October - December issue? Scan your own memory!

National Science Foundation - an Institution with a Unique History

True or False?

1.The fore-runner events of NSF began to unfold in January 1941 with the formation of the Chemical Society of Ceylon.
2.The CAAS was convinced that their failure to persuade the Government to establish a NRC was linked to the progressive activities of the non technical State officials.
3.It was clear that though the Government of the day proposed the setting up of a Ministry for Scientific Research, CAAS was not in favour of substituting such a Ministry for the proposed NRC.
4.It is remarkable that apart from issues concerning scientific research, all guest speakers at the inaugural ceremony of NSC, drew the attention of the new Council of the need to formulate a science policy for the country.
5.In 1970, NSC commenced one of its least important functions, that is, the awarding of grants for scientific research.

The need to make Science Popular and take to the people

True or False?

1.Pythagoras was the first person who proposed that the earth was round sometime around 500 BC.
2.Phlogiston theory of combustion was proved by Antoine Lavoisier, a French chemist during the period 1750 – 1800.
3.Modern science began in the 16th Century and thereafter a rapid development took place in the arena of scientific research.
4.Huttons theory during 1800 – 1850, which led to another change in the way of thinking of the society, enunciated that the age of the Earth must be much less than the then accepted belief of 6000 years.
5.The process of science popularization began in the early sixteenth century, with great difficulty, and is now a common practice.

Technological skills to win the World

True or False?

1.A nation that invests more on scientific and technological research will trend to grow faster than another country that depends on accumulating more capital, but investing less on R & D.
2.When analyzing global trends in trade, it can be clearly seen that products and introduction of medium to high technology exports have been decreasing over the last few years.
3.Transformation of the labour force into a skilled workforce should be a static process.
4.Even adaptation of technology to suit local conditions, need personnel with relevant skills.

5.Health information systems and healthcare practices in Sri Lanka rely largely on paper work and manual procedures, that are often complicated and time consuming.

Scientific research in a developing nation

True or False?

1.According to statistics from the Asian Region, India, South Korea, Japan and China collectively account for nearly 44% of the global R & D investment.
2.Though the treasury allocation for scientific research has increased over the last decade, the scientific publications have progressively decreased.
3.The contract research grants are expected to provide holistic and inclusive solutions for the research problems addressed.
4.If Sri Lanka is to keep up with the global developments, it is imperative that a critical mass of trained and skilled R & D personnel are nurtured continuously.
5.Lack of appropriate policies and state patronage are constraints not encountered by scientists in Developing countries.

Science for evidence based national policies

True or False?

1.A national innovation system can be perceived as a historically grown subsystem of the national economy.
2.A policy implies the product of democratic political process that gives a mandate to act.
3.Arthur Cecil Pigour argued that when economic activity creates external disservice, such as pollution, a properly designed tax policy will fail to improve resource allocations.
4.Economic analysis showed that there is a direct positive correlation between carbon tax and a country's GDP.
5.It is of a dubious nature as to how many policies that came out of different ministries have been successfully implemented with no clear implementation strategies.

National science library and resource centre assures global S & T literacy

True or False?

1.TEEAL provides an excellent collection of information in the field of agriculture centering 425 agricultural journals published by prominent publishers.
2.Publications which are available in digital formats are not available to viewers who wish to access full text journals.
3.Sharing of information relevant to science and technology to the society may ultimately provide the basis for economic development.
4.Some of the less popular techniques of science communication used today include the organization of Science Days for School children.
5.The scientific community now has the capability to take good advantage of accessing local magazine articles through advanced search tools by clicking the NSF Website.

Scientific writing and publishing: A way of communicating knowledge

True or False?

1.Written research articles and papers have to be published in academic journals or magazines for purpose of records.
2.A scientific paper is a written and published report describing original research results.

3.A scientific paper need not be simple, clear, impartial accurate, and structured logically.
4.Publishing research finding is not crucial for a career of an academic.
5.An indexed journal is a journal included in leading databases such as Science Citation Index, Scopus, PubMed, Hinari etc.

International Liaison to Develop Science in Sri Lanka

True or False?

1.The use of scientific collaborations among nations to address the common problems, it is important to build international liaison which has become an important topic currently.
2.Authorities need to take the initiative to involve scientists and provide adequate funding for research and development.
3.All scientists need not establish small and large as well as local and international networks in their respective disciplines.
4.Science as a tool for diplomacy has not been used for several decades by many countries around the world to bridge the global gap trough science.
5.NSF recognizing the importance and the current trends in the global arena, has promoted the creation of new networks with several countries to strengthen co-operation in areas of S & T.

The Secret of becoming a Successful Science Teacher

True or False?

1.NSF has shown that through drama and acting it is possible to instill in the minds of students the scientific concepts which are otherwise not easy to teach.
2.Even children who were very fond of science subjects began to dislike these subjects, and were not motivated to produce such dramas.
3.While being engaged with all these activities, I am unhappy not to have been able to conducted my teaching activities completely and complete the syllabus.
4.The students of our school were able to reach even international levels solely due to the encouragement provided by NSF.
5.The dramas that were produced on various themes were presented at the World Science Day, and won prizes.

Answers

01) 1. True, 2. False, 3. True, 4. True, 5. False
02) 1. True, 2. False, 3. True, 4. False, 5. True
03) 1. True, 2. False, 3. False, 4. True, 5. True
04) 1. True, 2. False, 3. True, 4. True, 5. False
05) 1. True, 2. True, 3. False, 4. True, 5. False
06) 1. True, 2. False, 3. True, 4. False, 5. True
07) 1. True, 2. True, 3. False, 4. False, 5. True
08) 1. True, 2. True, 3. False, 4. False, 5. True
09) 1. True, 2. False, 3. False, 4. True, 5. True

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