The Need to Make Science Popular and Take to the People

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"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".

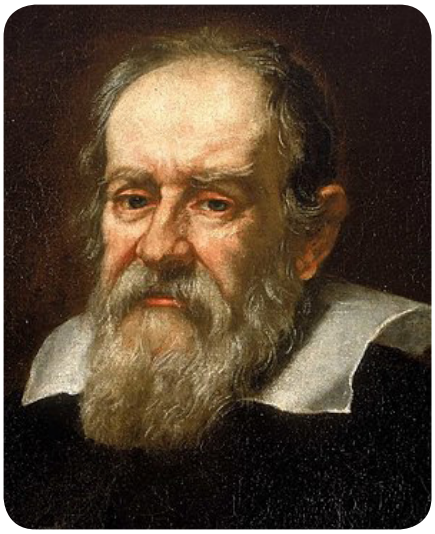

Fig.01 : Galileo Galilei - announced the Law of the falling objects

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

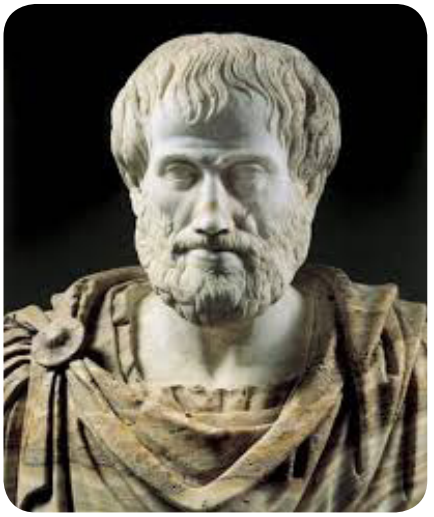

Fig.02 : Aristotle - ancient Greek Philosopher

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.

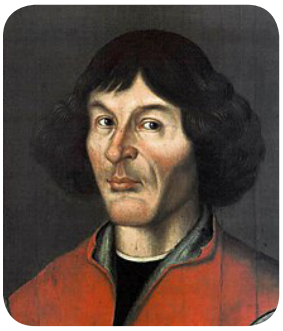

Fig.04 : Nicholas Copernicus - postulated that the Earth revolved around the Sun

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.

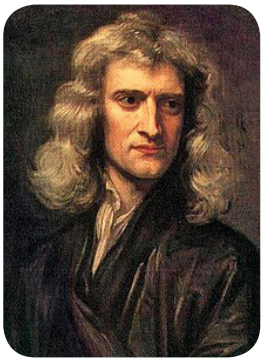

Fig.06 : Isaac Newton - disproved the belief that the force of nature were only affected through physical content

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.

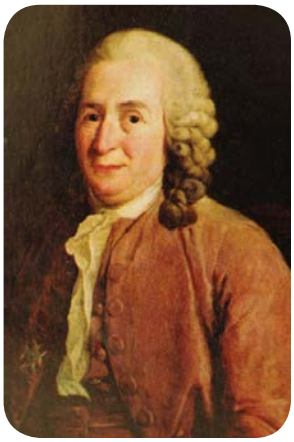

Fig.07 : Carolus Linneus - developed a uniform method of naming organisms

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.

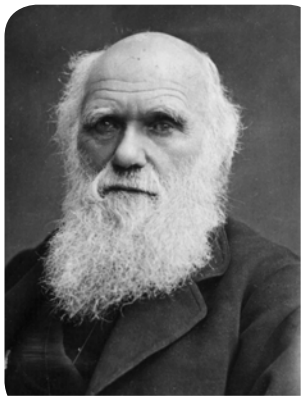

Fig.09 : Charles Darwin - changed the way people thought about the origin of human species

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.

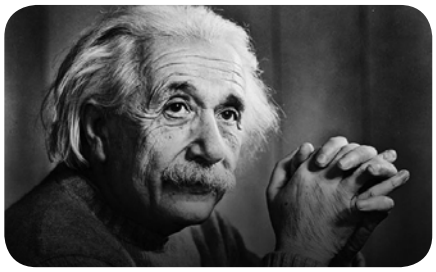

Fig.10 : Albert Einstein, became a key figure during 1900-1950 due to his theory of relativity

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,

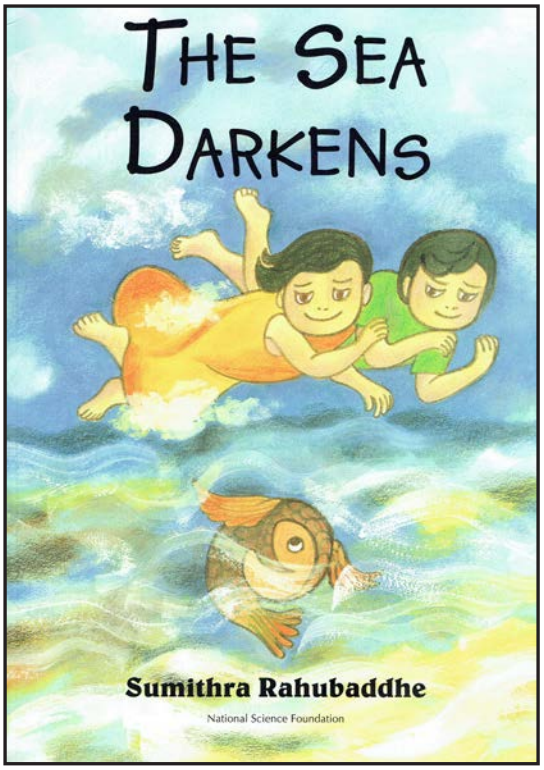

Fig.11 : The Sea Darkened - a children's story based on Tsunami

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.

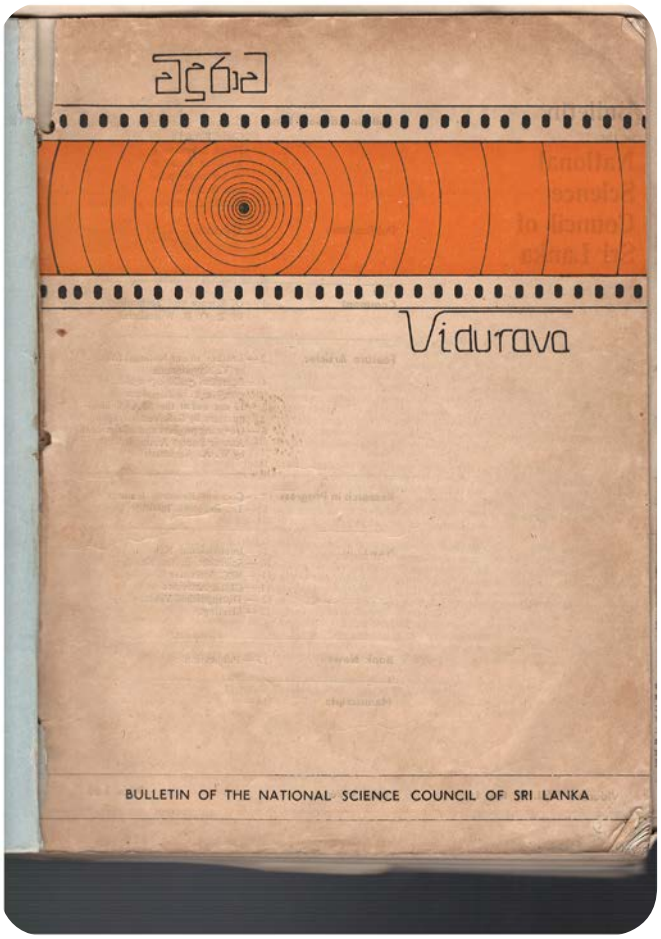

Fig.13 : The first issue of the Vidurava (Science Bulletin), 1976

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.

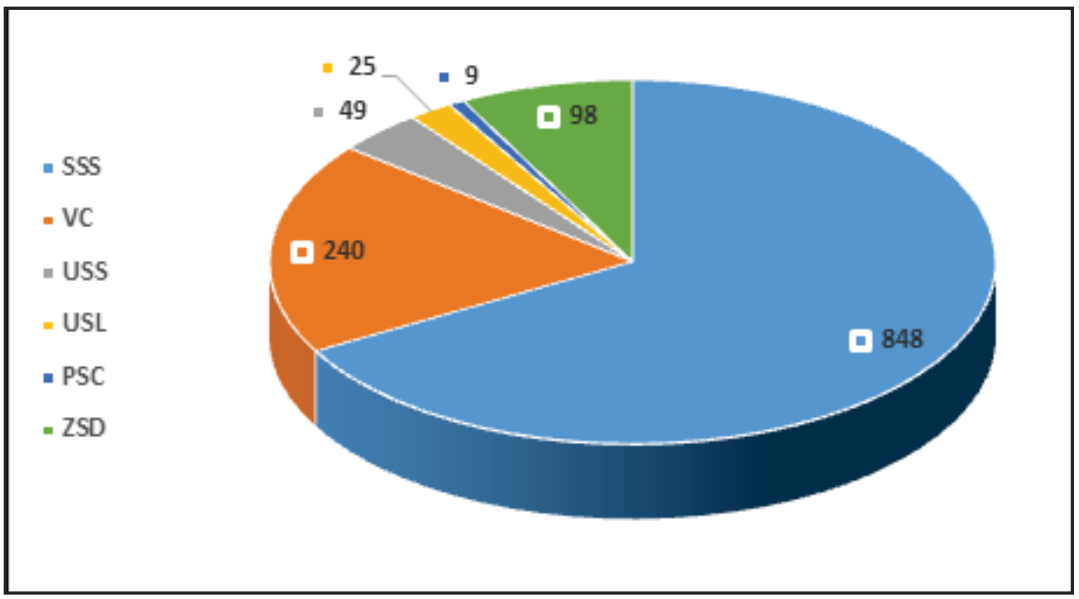

Fig. 14: Distribution of the Vidurava among stakeholders during 2017

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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