WORKING DOCUMENT

Guidebook series for introducing
Nuclear Science and Technology
in secondary education

GUIDEBOOK

1

Strategic partnership

January 2023

Foreword

The technical cooperation (TC) program is the International Atomic Energy Agency's (IAEA) primary mechanism for transferring nuclear technology to Member States, helping them to address key development priorities in areas such as health and nutrition, food and agriculture, water and the environment, industrial applications, and nuclear knowledge development and management.

The IAEA's technical cooperation programme combines specialized technical and development competencies. The results based programme aims at achieving tangible socioeconomic impact by contributing directly in a cost effective manner to the achievement of the major sustainable development priorities of each country, including relevant nationally identified targets under the Sustainable Development Goals (SDGs).

This important work can be seen through the efforts to enhance education and capacity building for future Nuclear Science and Technology (NST) resources through the TC regional project RAS0065 *'Sustainability and Networking of National Nuclear Institutions in the Asia and the Pacific region'*. This pilot project was the first of its kind in the IAEA program to revitalize NST in schools, specifically to inculcate scientific thinking related to NST among secondary students.

These efforts widened in 2018 with the TC regional project RAS0079 'Educating Secondary Students and Science Teachers on Nuclear Science and Technology,' which aimed to expand and sustain nuclear science and technology information, education and communication among secondary school students and teachers in the region. The target was to reach one million students by training educators through training courses for classroom curriculum and extra-curricular development. From 2018-2021, 8,351 teachers were trained in national courses and 191 teachers were trained through IAEA courses. Ultimately, over 1.6 million students were reached in the Asia and the Pacific region.

The TC project RAS0091 'Supporting Nuclear Science and Technology Education at the Secondary and Tertiary Level' started in 2022 and aims to expand the scope of collaboration to all partners in the region from the NST educational networks and secondary and tertiary level education.

Material developed through RAS0079 was successfully incorporated into secondary level education to support and strengthen continuous learning through enriching teachers and students' knowledge, skills and experiences of NST. These success stories and lessons learnt need proper reporting and documentation, not only as evidence but also to support knowledge sharing. They provide examples of best practice to assist all MS in implementing NST secondary education in a harmonized, consistent and efficient manner. This works in tandem with the IAEA mission to assist MS with scientific advice in nuclear science, education and training, and facilitates the sustainable transfer of knowledge.

The objectives of the guidebook series are to:

- strengthen or enhance existing curriculum programs by increasing capacity, sharing experiences, and forming collaborations and strategic partnerships with national and international partners
- provide a recommended framework for best practice NST secondary education curriculum teaching
- assist MS who are starting to develop and/or link NST to secondary education co-curricular activities to support deeper engagement in STEM with a focus on NST, and
- provide exemplary material that is suitable for teaching and learning for both classroom and outreach activities.

As such, the five (5) key areas proposed below are the basis of each important chapter:

GUIDEBOOK 1 — **Strategic partnership**

This guidebook represents the overarching framework for NST secondary education. It describes the partnerships that MS need to have in place to support good governance and achieve successful implementation. At the same time, linkages with other organizations such as NST-related organizations, stakeholders, academia and professional non-governmental organizations (NGOs) are highlighted as part of their contribution to the project.

GUIDEBOOK 2 — **Linking NST with the school curriculum**

The second book is all about the various approaches that have been taken in developing NST topics to be included in RAS0079 — *Educating Secondary Students and Science Teachers on Nuclear Science and Technology*. It consists of analysis, design and review. It also features the curricula used by various MS in implementing NST as part of a case study that allows others to appraise which of these implemented curriculum suits their country and priority needs. In addition, best practice can be identified, as well as suggested improvements for the inclusion of NST topics in school curricula.

GUIDEBOOK 3 — **Co-curriculum development**

The third book explains the extension activities, programs and learning experiences that are designed to complement the formal curriculum activities and achieve greater engagement from students. These can be in the form of contests, cultural shows, visits and exhibitions.

GUIDEBOOK 4 — **Teaching strategies and learning facilitation tools**

This guidebook details the support from learning materials and instrumentation that is necessary for effective learning. At the same time, lesson exemplars from teachers showcase the development of traditional ways teaching and fact-based learning — which relies on the teacher presenting facts and their own knowledge about the subject — towards inquiry and phenomena-based learning. Inquiry and phenomenon-based learning are learner-centered and demonstrate best practice. These examples seek to inculcate and promote NST learning in effective and interactive ways.

GUIDEBOOK 5 — **Assessment, monitoring and evaluation**

Lastly, the fifth guidebook illustrates the need for many countries to develop appropriate methods to monitor teaching efficiency and assess students' knowledge, attitude and practice with regard to NST education, as well as reviewing the overall curriculum.

Note for the users

As a focal activity of the project, this publication is based on discussions held during workshops and meetings regarding the development of a guidebook series that documents all relevant information crucial for the successful implementation of NST secondary education. The guidebooks are expected to provide guidance to any MS, through their nuclear or education institutions, to initiate or enhance the NST topic/syllabus for students and teachers at the secondary education level.
The guidebooks offer lesson plans for curricular and co-curricular activities as well as demonstrating creative ways to deliver knowledge through state-of-the-art pedagogical approaches. The series seeks to leverage the existing curriculum in each country so as to mainstream NST and promote awareness and understanding about its peaceful uses.

This particular guidebook describes arrangements that represent good governance and are needed for the sustainability of NST secondary education using examples from Malaysia, Philippines, Indonesia and Oman. It identifies key partners with the knowledge, skilled people, processes and management expertise to enhance NST education, as well as making suggestions for the best NST partnerships for the implementation of continuous NST lifelong learning.

Disclaimer

The views expressed in this publication are those of the participating IAEA MS under the TC projects RAS0079 and RAS0091. Guidance provided in this manual, describing best practice, represents expert opinion in terms of secondary education but does not constitute recommendations made on the basis of a consensus of MS.

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Contents

List of abbreviations

AELB	Atomic Energy Licensing Board
Argonne	Argonne National Laboratory
BATAN	National Nuclear Energy Agency of Indonesia
BRIN	*Badan Riset dan Inovasi Nasional Indonesia* National Research and Innovation Agency of Indonesia
DepEd	Department of Education
DOST	Department of Science and Technology
DOST-PNRI	Department of Science and Technology - Philippine Nuclear Research Institute
DOST-PSHS	Department of Science and Technology – Philippine Science High School
DOST-SEI	Department of Science and Technology-Science Education Institute
IAEA	International Atomic Energy Agency
MoE	Ministry of Education
MoU	Memorandum of Understanding
MS	Member State
nSTEp+	NST Education Program in the Philippines
NST	Nuclear science and technology
NUTEC	NUclear TEChnology
PNRI	Philippine Nuclear Research Institute
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering and Mathematics
VUCA	Volatile, uncertain, complex and ambiguous

1. Introduction

Nuclear science and technology (NST) continues to gain popularity, with a major role in bringing innovation and harnessing benefits for everyone, as well as offering solutions to various global issues. In general terms, nuclear science is the study of the atomic world, while nuclear technology is defined as technology that involves the nuclear reactions of atomic nuclei. NST is thus the field of atomic study and its technology, involving the nuclear reactions of atomic nuclei.

The application of NST for peaceful purposes includes the use of nuclear power as an element of sustainable and green energy. Another important use is in the management of plastic pollution. NUclear TEChnology for Controlling Plastic Pollution (NUTEC Plastics) is building on International Atomic Energy Agency (IAEA) efforts to deal with plastic pollution through recycling using radiation technology as well as marine monitoring using isotopic tracing techniques. It provides science-based evidence to characterize and assess marine microplastic pollution, while also transforming plastic waste into reusable resources using ionizing radiation. A further application can be observed in the use of isotope techniques in dealing with salinity and drought conditions in salt affected agricultural lands under the Cooperative Agreement for Arab States in Asia.

In order for NST exploration to continue, future generations need to have access to the appropriate education to promote the growth of the field and unlock potential world benefits. Current education systems therefore need to introduce NST at an early stage, in order to inculcate interest in the subject matter and eventually produce NST experts with the knowledge and skills to feed future resources.

Responsibility for the introduction of NST teaching and learning in secondary school education is currently shared between various national stakeholder organizations, each of which has its own mandate, structure, area of expertise, resources and collaborators. As such, it is quite likely there will be several organizational entities involved in the development and implementation of any future NST education program, with each organizational entity having a specific role to play during certain phases, and responsibilities evolving as the program implementation advances.

In the face of a world that is becoming increasingly volatile, uncertain, complex and ambiguous (VUCA), education can determine whether people embrace or are defeated by the problems they encounter. Schools face a range of changing educational demands from learners, society and the labor market. In particular, where the use of NST has been identified as offering possible solutions for many global issues, the school education system needs to understand its importance in creating future NST-trained generations who can respond to the challenges of the 21st century and hopefully achieve the United Nations' Sustainable Development Goals (SDG).

Education is based on networks of interdependent and yet linked actors whose actions impact others, who evolve, adapt and reorganize themselves through collaboration and communication based on formal or informal arrangements within their learning systems. Because of this, it is important for this guidebook to include a specific chapter that emphasizes the importance of strategic governance. Thus, examples provided may facilitate other MS who wish to implement and enhance their own NST secondary education. Similarly, by bringing countries together to learn from each other, critically reflect and create together the work we do can be made relevant to other MS. The ideal is to offer a harmonized program that is adaptable to all education systems, while also acknowledging that each country's education system is different and highly complex.

Nuclear science and technology continues to gain popularity, with a major role in bringing innovation and harnessing benefits for everyone, as well as offering solutions to various global issues.

2. Good governance in education

Governance which represents the people, structures and processes creates an overarching frame that is essential to any social endeavors, including the education system. Effective leadership and governance are necessary for a better school culture and ethos which together allow for positive community interactions and the creation of a long-term beneficial environment. The European Commission, Ministries of Education and European stakeholder organizations have collaborated on the governance of school education, and the heart of their vision for this governance is the concept of schools as part of an integrated learning system. Their belief is that within each country or region, policymakers and other stakeholders have the capacity to plan and work together towards shared goals and make positive change happen. This capacity to engender change, based on evidence, reflection and shared practice, in turn ensures that policy reform has a lasting positive impact.

It is important to understand who are the key people and organizations, as well as what are the essential components required for development (see Figure 1). A strategic vision and leadership, with multiple stakeholders responsible for school development and a level of professional collaboration will determine the success of any school as a learning organization. At the same time, local and international collaborative research, networking and continuing professional development will motivate and empower teachers and school leaders to simultaneously improve both their educational and organizational practices. As such, developing the capacity and role of teachers and school leaders is essential so as to provide a clear strategic vision and leadership that guides and fully supports teaching and learning, while enabling effective communication with other practitioners and stakeholders.

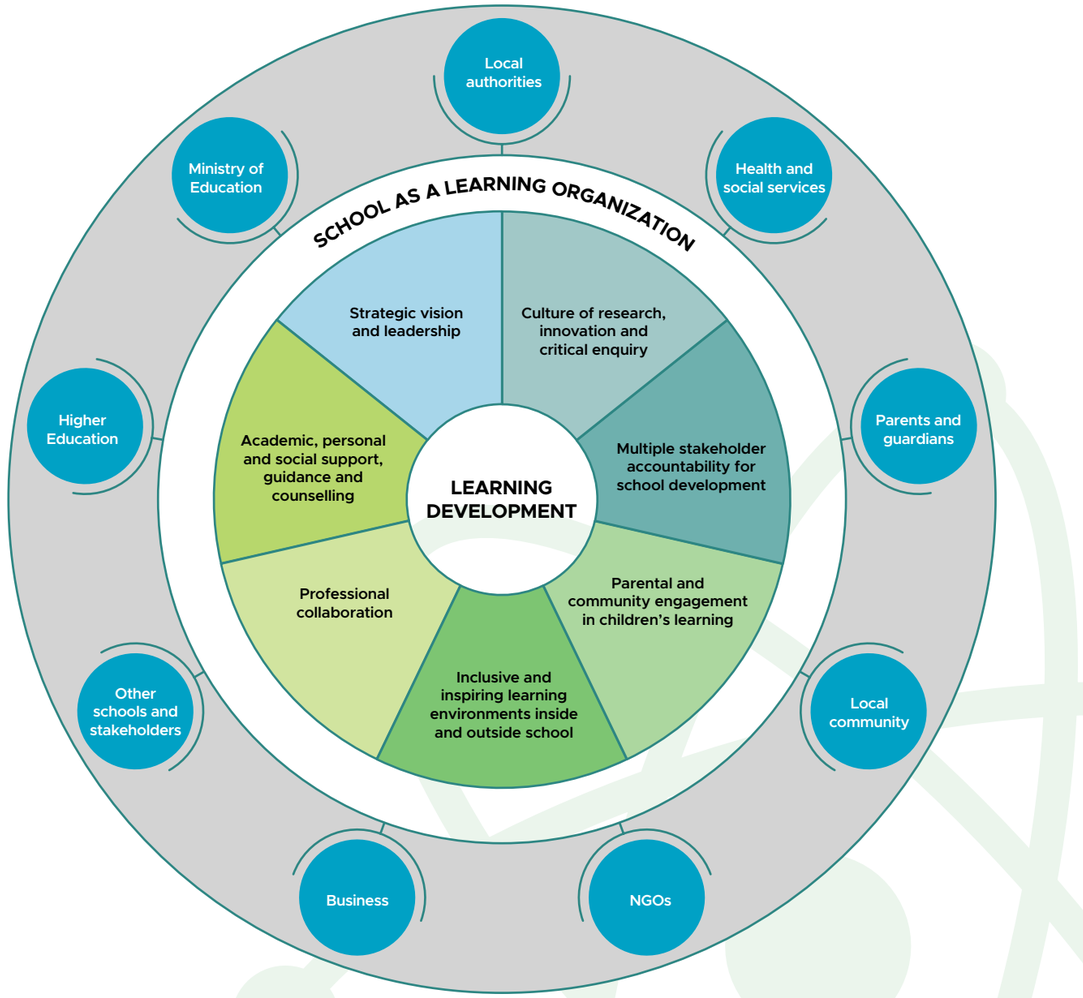

Figure 1.
The different elements of schools as learning organizations
(Source: ET2020 Working Group on Schools, European Commission, 2018)

In order to ensure the successful design and implementation of NST resources within the secondary school programs, key national stakeholders must examine a wide variety of concerns. Infrastructure and logistics are among the challenges, as are a sufficient budget and availability of qualified people capable of delivering NST education. It is critical to have a comprehensive grasp of the nature and scope of the tasks involved, as well as any potential ramifications, in order to support an informed discussion and any decision making that may result. This further translates into the need for a set of responsibilities and the procedures exercised by institutions or governments in providing strategic direction. This will ensure educational objectives are achieved through effective and efficient use of resources, accountability, and the participation of relevant people in decision making.

Good school-based governance partnership should:

- involve the collective participation of all key stakeholders in school management
- lay a solid foundation for the long-term development of the school as the cornerstone of quality education
- ensure that the use of public funds is appropriate and in the best interests of students and the community
- enhance the efficiency, effectiveness and overall performance of administrative management, which is crucial to the continuous development of the school
- boost the confidence of parents and the public in the school.

When all of these things are in place, learning institutions such as secondary schools can perform their responsibilities and enact procedures, which ensure the effective and efficient use of resources, accountability and participation from the relevant people.

Through the RAS0065 Project, the various stakeholders within MS with responsibility for the introduction of NST education and resources were identified. Figure 2 provides an overview of some of the key issues that need to be considered by these stakeholders in the successful design and introduction of NST resources.

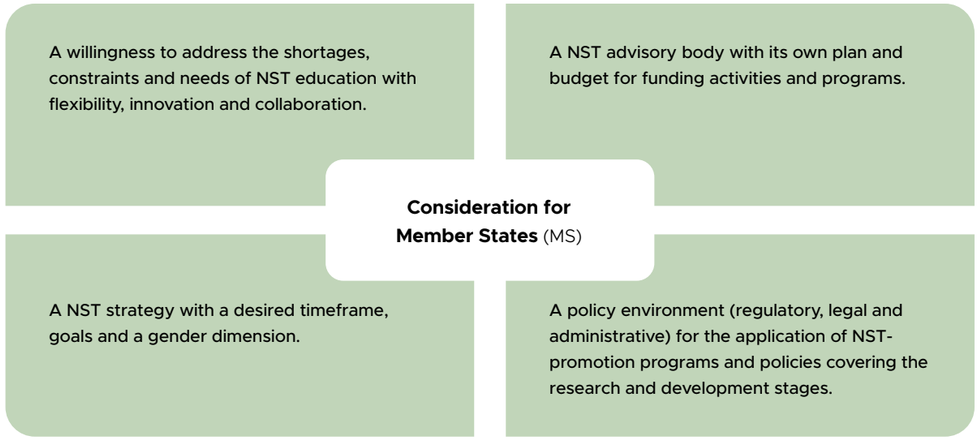

Figure 2.
An overview of the issues to be considered by the national stakeholders for the successful design and introduction of NST resources

The most critical part of developing a strategy for good governance on the introduction of NST to secondary schools is to design an initial or pilot program. A Pilot program, outreach or extra-curricular activity, is recommended to assess potential nuclear introduction activities for national implementation. The pilot program's successful implementation could lead to integrating NST into the curriculum system.

Furthermore, a pilot program can help MS identify the right stakeholder.

As a reference, some of the steps needed to start the pilot program can be seen through the seven-stage flowchart in table 1, which illustrates a framework to assist the initiation of building support for an outreach (extra-curricular) program for nuclear science and technology in secondary schools.

Table 1.
Seven-stage Flowchart in Initiating NST Education Program.

STAGE 1	**Identify the project manager**	A qualified project manager should be identified as soon as possible to implement activities and programs. The project manager needs to have the support of his/her management with a level of flexibility to work among stakeholders, partners, and participants to provide seamless integration of all goals and objectives in a high-quality manner. This person should also possess the skills necessary to address situations and audiences with creativity and diplomacy
STAGE 2	**Understanding of the education system**	It is recommended that the project manager develops a good understanding of the education system. The project manager should recognize and understand the constraints and opportunities of the stakeholders and partners including schools. This recognition and understanding should lead to additional identification of opportunities and willingness to establish new initiatives. It is also important that that the project manager has a good understanding of the secondary school structures, expectations, and systems.
STAGE 3	**Review of the sample resources or activities**	Review the sample resources and activities from IAEA pilot countries. The sample of activities can be seen in the document A Compendium of Resources and Activities for Teachers and Students. The project manager can also refer to other sample resources from relevant national organizations.
STAGE 4	**Understand the local obstacles and opportunities**	It is also recommended that the project manager identifies any barriers and needs of the teachers and students who are expected to participate due to local attitudes/perceptions related to nuclear science and technology activities, transportation limitations, constraints of educators, partners, and stakeholders. The project manager should also search out opportunities to engage and involve community, local government, research institution, education sector, and even industry partners who may be willing to assist him/her. The project manager should realistically plan according to the budget available to implement selected activities for the short, medium, and long term.
STAGE 5	**Propose a custom pilot programme(s)**	Resources and activities should be selected to fit the needs and complement the education system in the country and with the optimum likelihood for implementation considering the local constraints and opportunities. The programme should be the result of a close collaboration of all relevant stakeholders and partners (e.g. local educators, government, nuclear, and other industry partners).
STAGE 6	**Introducing activities into school**	Specific information can be found for this stage in the "Compendium User's Guide to Introducing Extra-Curricular Activities into Secondary Schools"
STAGE 7	**Evaluation**	An important aspect of managing any activity or programme is the evaluation of outcomes. This should include the design of realistic established deliverables for monitoring the implementation of the programme and for tracking outcomes for example, the number of teachers or students participating in the programmes and activities, their views on nuclear science and technology before, during, and after participation, and the evolution of their education and career plans. The evaluation process should also include timelines with specific deliverables and/or expectations.

3. Partnership in NST Education

Partnerships are one means of enhancing this type of governance effectiveness through:

a) Relationship effectiveness, including:

- partner contribution compliance,
- meeting respective partner objectives,
- value-add related to effectiveness and efficiency (necessarily impressionistic with anecdotal evidence)

b) Reduction of transaction costs through enhanced or shared ability to:

- measure the costs and benefits of producing goods and services,
- protect property rights,
- enforce agreements,
- integrate dispersed knowledge,
- reduced free ridings

c) Effectiveness reinforcement through:

- perceived effectiveness and willingness to continue expected contributions,
- availability of scientific knowledge to support decisions.

An educational partnership occurs when two or more parties (from academic or non-academic sectors) come together for the common good of a school or to enhance student learning. Partnerships can take the form of cooperation or collaboration. The former is simply defined by a condition or state where a group of people or organization work in *support of another's goals*, while the latter involves a group of people or organizations coming together and working on a project in *support of a shared objective, outcome, or mission*.

The identification and securing of relevant stakeholders, organizations and target participants for a governance framework educational partnership might include:

- local secondary schools
- local and regional colleges/universities
- industry
- professionals and their various employment organizations
- workforce agencies, boards and ministries
- educational agencies, boards and ministries
- local elected, selected and appointed community leaders who are decision makers, influencers and constituents.

Any partnership needs to be based on transparency, responsibility and accountability, as well as mutual trust and respect that can benefit all parties in a proactive manner to bring about:

- more open communication and collaborative/ cooperative partnering
- resource availability
- leveraging of existing resources to meet new targets
- motivation
- talent discovery
- performance enhancement
- human resource sustainability.

Such partnerships can be formalized in the form of an agreement, for example a Memorandum of Understanding (MoU). An MoU is a non-binding agreement that is essential for establishing coordinated efforts in a partnership between two parties or more, and aims to express a shared direction and set of goals. It also provides a roadmap of each party's duties and requirements. Some of the benefits to formalizing a partnership through an MoU include:

- a tool for integrating the partnership into the strategy and ethos of the school
- an opportunity to safeguard the partnership by ensuring orderly transitions through staff changes
- an opportunity to build a shared responsibility for delivery and ensuring that the workload does not fall on a small number of individuals
- an opportunity to build an impact evaluation into the partnership from the outset and clearly establishing the achievements it hopes to realise.

The agreement in conducting an NST education program requires a strong understanding so it can be formalized into an MoU. However, the MoU agreement process requires effort, intense communication, commitment, and clear benefits for each party. In the case of NST education, national implementation through collaborative activities can be used as a pilot for the MoU agreement. This means that the NST education program can still be implemented without a formal MoU due to the strong cooperation and interest between the parties. However, to ensure long-term sustainability, avoid negative impacts from dynamic situations in the future, and even expand the implementation area, a formal agreement through an MoU is highly recommended. The form and level of the MoU will vary. That is, the needs of MS will be different, as well as the structure of the parties. A bilateral or multilateral agreement, such as an MoU between relevant agencies, is important in partnership.

4. Strategic partnering in NST education

While some MS experienced difficulties in starting cooperation or collaboration to build partnerships, both the RAS0065 and RAS0079 Projects demonstrated that partnership is essential for successful educational programs. Each collaborating party was shown to be vital in maintaining the program's sustainability, whether they were educational or research entities. The research institutions or nuclear agencies provided technical resources and expertise, while the education sector's strength lay in teaching resources, formal curricula and educational infrastructure. As several MS pointed out during discussions, partnership was the key when one or more of cooperating and collaborating entities faced limitations.

Building and fostering partnerships starts at the identification stage:

- what are the individual needs?
- who are the helping partners?
- what are the requirements of potential partners?

Examples of how to develop a partnership strategy in NST education can be seen in Table 1. This table describes the framework that functions as a guide in forming and maintaining a strategic partnership, adapted from *Strategic Partnering: A Guide to The Conceptual Framework*. The framework is made compatible with nuclear and academic sectors by positioning the project counterpart as an individual organization.

Table 1.
Conceptual framework of strategic partnering (Rogers, Kent & Lang).

	Individual organization	Partnership activities	Criteria/Indicators
Organization assessment	Define goals/ priorities	Individual organization has common goals with potential partner	• Know the organization goals and missions • Determine the readiness to partner (staff, resources, time, skill, expertise) • Identify key persons within the organization to participate/contribute • Know the organization limitations
Partner selection	Identification of partner and resources availability	Each organization defines contribution and level of partnership	• Determine a "shared" vision • Evaluate any previous history with other organization(s) • Determine what the organization can offer to the other organization(s) • Determine what type of resources that each organization can bring • Assess whether the partner has resources that the organization needs/wants • Determine the mutual benefit • Agree upon the level and type or partnership (formal, informal, one-time, long term) • Confirm that there is no conflict of interest, either within or between organizations • Confirm that the partnership has a unique purpose that is not meet by any individual organization
Partnership building	Commitment and individual roles	Each organization defines specific roles and outcomes	• Agree the workload distribution • Decide the frequency of communication and report – *frequency should depend upon level and type of partnership* • Establish a timeframe for completion of the project • Decide on a process to overcome barriers, conflicts, or obstacles if necessary • Define measurable indicators • Consider the need for adding new partner(s)
Monitoring and evaluation	Re-prioritize, if necessary, assess progress and outcomes	Maintenance and evaluation	• Determine that individuals are contributing to the achievement • Follow up the progress • Assess the structure of the partnership • Consider if re-establishment is needed • Assess the measurable outcomes • Assess the sharing • If the goals are not being met, consider to re-assessing the outcomes, priorities, and work group • Make sure that individual organizations are active listeners

Mapping the critical stakeholders is a crucial early stage in the partner identification process. Appropriate stakeholder mapping will solve an individual organization's limitations and improve resource efficiency, as explained in the good governance section above. Mendelow's matrix allows for the division of stakeholders into resource efficiency categories. Both Figures 3 and 4 indicate methods that can be used to map both stakeholders and treatment in order to get support with efficient resources.

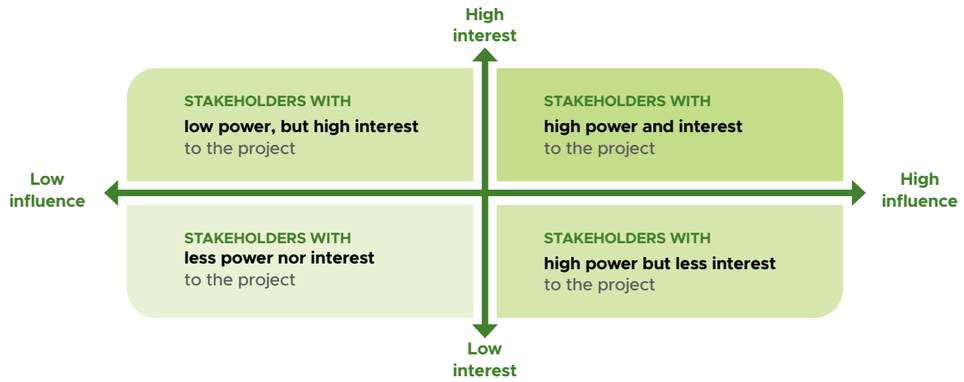

Figure 3.
The Mendelow's Matrix for Stakeholder Mapping.

Stakeholders are placed in the four matrices in Figure 3, according to their level of influence (power) and interest. The level of influence indicates the stakeholder's power in terms of the project (regulation, resource, infrastructure, human capital), while the level of interest indicates the stakeholder's willingness to join the project. Figure 4 offers a guide for enhancing the role of stakeholders. Since each matrix has characteristics, treatments (communication, involvement in activities, meetings) they do not need to all function at the same intensity in order to ensure resource efficiency.

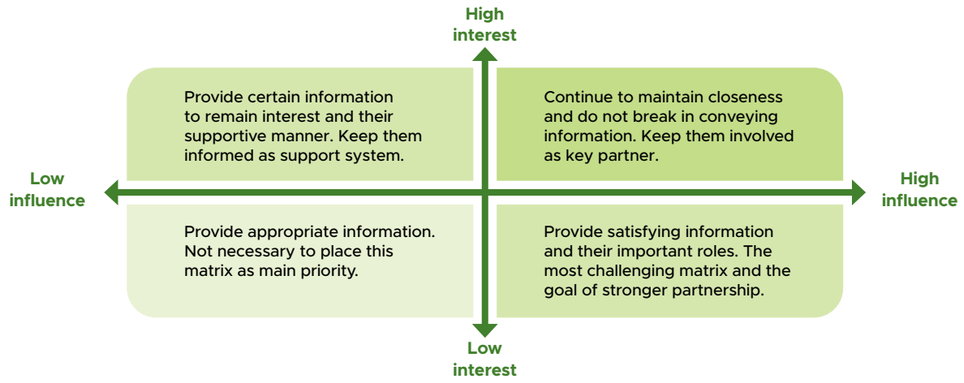

Figure 4.
The Mendelow matrix for stakeholder mapping.

5. Existing partnerships

As part of the RAS0091 Project — *Supporting Nuclear Science and Technology Education at the Secondary and Tertiary Level* — participants from six (6) secondary schools representing Malaysia, Philippines, Indonesia and Oman came together for an inaugural meeting. During this meeting the governance of each organization and its existing partnership was explored. The discussion was further divided into discussion around different levels of partnership: local, national and international.

5.1 Local/national organizations

Governance through partnership is a key element in the implementation of a successful education system. As such, discussion at the Regional Meeting focused on further understanding what kind of partnerships exist among MS and how they have achieved implementation of NST in their secondary education systems.

It is now known that governance through partnership is a key success to the implementation of an education system.

Some partnerships can be formalized in the form of agreement, for example, a Memorandum of Understanding (MoU). An MoU is basically a non-binding agreement that is essential in establishing coordinated effort in a partnership that expresses a shared direction and set of goals. It provides a roadmap outlining each party's duties and requirements. In formalizing a partnership, the MoU can serve as:

- a tool for integrating the partnership into the strategy and ethos of a school
- an opportunity to safeguard the partnership by ensuring orderly transitions through staff changes
- an opportunity to build a shared responsibility for delivery, ensuring that the workload does not fall on a small number of individuals
- an opportunity to build impact evaluation into the partnership from the outset and clearly set out the projected achievements.

Details of the MoUs among MS, taken from the RAS0079 Project report in 2021, with regard to the project to educate secondary students and science teachers in NST, are shown in Table 2.

Table 2.
List of MS with partnerships as at 2021.

MS	Lead institution	Partner institution(s)	Formalized by MoU
Indonesia	National Nuclear Energy Agency (BATAN)	• Center for Curriculum and Books — Ministry of Education • 15 secondary schools in (Jakarta, West Kalimantan, Bangka Belitung Island, Banten, Central Java, and East Java)	Yes ✔
Iran	Nuclear Science and Technology Research Institute	• The Ministry of Education • Nuclear Society of Iran • Ministry of Education • Physics Teacher Society of Iran • OMID TV of Islamic Republic of Iran Broadcasting • Nuclear Power Production and Development company of Iran	Yes ✔
Jordan	Ministry of Education	• Jordan Atomic Energy Commission	No ✖
Malaysia	Malaysian Nuclear Agency	• Ministry of Education	No ✖
Mongolia	Executive Office of the Nuclear Energy Commission	• Teacher Professional Development Institute	No ✖
Nepal	Ministry of Education Science and Technology	• Curriculum Development Centre	Yes ✔
Oman	Ministry of Education	• Peaceful Nuclear Technology Office — Ministry of Foreign Affairs	No ✖
Philippines	Philippine Nuclear Research Institute	• Department of Education • Philippine Science High School System • Department of Science and Technology — Science Education Institute (DOST-SEI)	Yes ✔
Sri Lanka	Sri Lanka Atomic Energy Board	• Science Branch of Ministry of Education Sri Lanka • Science branch of National Institute of Education	Yes ✔
Syria	Atomic Energy Commission of Syria	• The Ministry of Education	No ✖
Thailand	Thailand Institute of Nuclear Technology	• Office of the Basic Education Commission • Princess Chulabhorn Science High Schools • Electricity Generating Authority of Thailand	Yes ✔

The Republic of the Philippines has established a strong partnership at the local level. Figure 5 outlines the respective organizations:

Department of Science and Technology — Philippine Nuclear Research Institute (DOST-PNRI)	**Department of Science and Technology — Philippine Science High School** (DOST-PSHS)
Department of Science and Technology — Science Education Institute (DOST-SEI)	**Department of Education**

Additionally, the Department of Education is further divided into the Central, Regional and Schools Division Offices. Through this structural partnership, information is circulated between the IAEA, PNRI, DOST and the Department of Education.

Partnership institutions

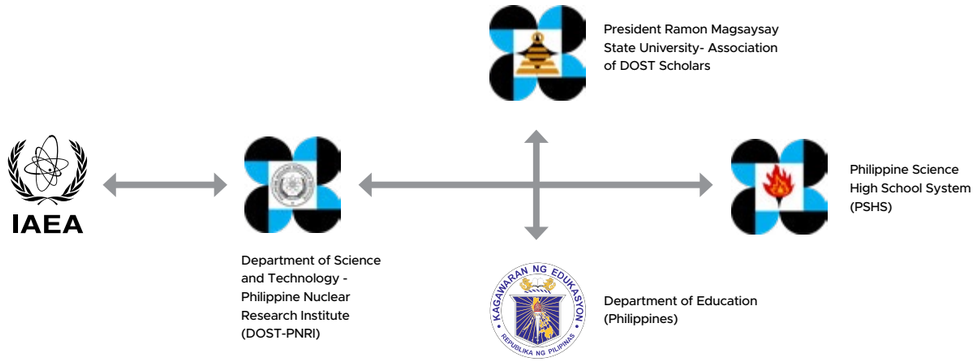

Figure 5.
The Philippines partner institutions for NST secondary education.

Such a partnership ensures the efficient implementation of NST-related activities in the country, such as the NST Education Program (nSTEp+). Lead by PNRI, nSTEp+ provides opportunities for K–12 students and teachers to promote the peaceful uses and applications of NST, while enriching students' and teachers' knowledge, skills and experiences in science. These opportunities include:

- partnerships/collaborations in undertaking NST-related research or science investigatory projects
- development of teaching and learning resource materials
- teacher training
- internships
- other outreach programs/activities.

Indonesia has had a National Nuclear Education Program since 2000 and the RAS0079 Project was able to enhance this program through cooperation between the National Nuclear Energy Agency (BATAN) and the Ministry of Education (MoE). The collaboration between these two organizations began when BATAN conducted a feasibility review of nuclear and radiation topics in school textbooks. BATAN carried out this review with curriculum researchers from MoE, seeking to provide a balanced understanding of NST and improve nuclear content, so that students can accept this technology more positively. This partnership included several programs:

- curriculum revision
- teacher training design
- teacher handbooks
- interactive teaching materials for students.

2008	• Nuclear Goes to School initiated to conduct NST introduction for students
2009	• Education research: Nuclear topics on sciences curriculum • Reviewed nuclear topics on natural sciences based on current curriculum
2010	• Collaboration continued • Drafted and proposed nuclear topics on formal science curriculum for secondary level • Together, produced nuclear supplementary materials for teacher hand book, called NUCLEAR SMART BOOK
2011	• Nuclear competition for student and nuclear ICT competition for teacher were held annually. To find potential education stakeholders
2013	• Nuclear introduction workshop for teacher • Tripartite discussion about nuclear topics on academic curriculum and how to implement
2014	• BATAN established Public Education Sub Division for nuclear education and dissemination purposes
2014 - 2017	• The collaboration met with the IAEA program to implement nuclear science in academic activities • Through previous workshops, potential schools were identified to become pilot schools • Started to conduct advanced workshop for pilot school teachers, with IAEA experts • Implemented nuclear topics on curriculum and enrichment activities, based on school's policies • Circulate information through teacher communities and next workshop to find other potential pilot schools

Figure 6.
Indonesia — timeline for initiating BATAN–MoE collaboration.

Additionally, an MoU was made between BATAN and Indonesian secondary schools with the aim of having more national NST-related programs, developing outreach activities and exhibitions, disseminating NST knowledge, and ensuring teachers can utilize the available tools and teaching materials.

However, further reform by the Indonesian government (with the motive of improving efficiency and coordination through creating a "home base" for research and innovation) has resulted in the formation of the National Research and Innovation Agency (*Badan Riset dan Inovasi Nasional*, BRIN) a cabinet-level government agency. Through this reform BATAN has been merged with other research centers that were scattered across various government agencies and ministries. This means that nuclear research activities and education/curriculum researchers are currently working within the same organization.

In Malaysia, a strategic collaboration between the Malaysian Nuclear Agency and the Ministry of Education has resulted in a shared vision related to NST in secondary education including its inclusion in the new Malaysia curriculum, rolled out in 2017. This new curriculum is in line with the Education Blueprint 2013–2025 (Figure 7) and aims to strengthen STEM. Through this new curriculum, Malaysia was able to integrate NST-related topics into the national curriculum and instigate various activities to empower teachers in teaching these topics.

Science, Technology, Engineering and Mathematics (STEM)

The Ministry will ensure that it prepares students with the skills required to meet the challenges of a world that is being transformed by the applications of Science, Technology, Engineering and Mathematics (STEM). It will also work in laying the foundations at the school level towards ensuring that Malaysia has a sufficient number of qualified STEM graduates to fulfill the employment needs of the industries that fuel its economy. Measures undertaken will include:

- **Raising student interest trough new learning approaches and an enhanced curriculum:** Incorporating higher-order thinking skills, increased use of practical teaching tools and making the content relevant to everyday life to increase interest;
- **Sharpening skills and abilities of teachers:** Training teachers in primary and secondary schools to teach the revised curriculum; and
- **Building public and student awareness:** Increasing parents and students' STEM awareness through national campaigns.

Figure 7.
Malaysian Education Blueprint 2013–2025.

Likewise in Oman, nuclear science has been incorporated into the science curriculum, mainly in the Grade 12 Physics curriculum. The participation of Oman in the RAS0079 Project has further enhanced the activities of NST educators among secondary schools via the increased implementation of curriculum and extra-curricular activities.

NST partnerships have focused on outreach activities during last three (3) years, with educators partnering with energy companies in funding activities to enhance better understanding of NST among students and teachers. For examples, the OQ Company are a partner in two national workshops — "Innovative Approaches in Teaching NST for Secondary School Students" (December 2018 and December 2021). The partnership also funded the Enrichment teacher guide for teaching NST. In addition, various private sector companies are the main sponsors for the Oman Science Festival, where interactive activities were presented to the visitors. The Ministry of Education of Oman has also signed an agreement with the Al Batinah Energy Company and Al Suwadi Energy Company to finance NST activities in schools. During 2022, these activities included a variety of competitions and events for students and teachers, as well as the local community, with the aim of raising the level of awareness and knowledge of nuclear sciences among various segments of society.

Table 3.
Details of existing partnerships developed by country.

Country	Organization	Function/Activity
Indonesia	• **BATAN/BRIN** • **Center for Curriculum and Books – Ministry of Education** • **School partners**	• Conducted training and courses on NST for teachers and students in Indonesia • Visited schools to explain NST either in person or virtually • Organized school visits to respective organizations • Reviewed the updated NST topics in the student textbook • Produced a handbook for teachers • Trained teachers on how to insert NST topics into lesson plans and curriculum • Implemented teaching materials including training models for other teachers/schools
Malaysia	• **Ministry of Science, Technology and Innovation** (MOSTI) • **Ministry of Education** • **Malaysian Nuclear Agency**	• Organized an annual "National Science Week" • Conducted regional NST workshops for science teachers • Conducted workshops for school students on the implementation of nuclear education modules developed by Japan to determine their practicability • Organized a program called Nuclear Science and Technology for Secondary Schools
Oman	• **Ministry of Education, OQ Company and Peaceful Nuclear Technology Office** • **Ministry of Education and Al Batinah Energy Company and Al Suwadi Energy Company**	• Organized national workshops in NST for science teachers • Cooperated in organizing the Oman Science Festival • Conducted competitions for teachers and students, as well as workshops for teachers

Philippines	• **Department of Science and Technology - Philippine Nuclear Research Institute** (DOST-PNRI)
	• **Department of Science and Technology-Science Education Institute** (DOST-SEI)
	• **Department of Science and Technology – Philippine Science High School** (DOST-PSHS)
	• **Department of Education** (DepEd)
	  ▪ Central Office
	  ▪ Regional Office
	  ▪ Schools Division Office
		• Organized a National Science and Technology Week
		  ▪ showcasing research and career opportunities in science
		  ▪ promoting scholarships within Philippine Science High School (PSHS) System
		• Conducted a Science and Technology Fair, quiz competitions, teacher-training related to NST, and dissemination of information related to NST, including memoranda and advice regarding different activities conducted in coordination with PNRI
		• Connected teachers and learners to the PNRI for mentoring and coaching and work immersion

5.2 International partnerships

Through an MoU signed in 2018, the Philippines joined an IAEA education project, marking a significant step forward in the teaching of NST in secondary schools (Figure 8).

Figure 8.
The DOST-PNRI partners with the Department of Education as part of the IAEA Regional Technical Cooperation Project on Nuclear Science and Technology Education.
Source:
https://pnri.dost.gov.ph/index.php/2-uncategorised/522-dost-pnri-partners-with-DEPED-in-iaea-regional-technical-cooperation-project-on-nuclear-science-and-technology-education

Another partnership that was common to all MS was the Regional Training Course for teachers that was conducted face-to-face (prior to the pandemic) and virtually (during the pandemic) by the Argonne National Laboratory (Argonne). Argonne is basically a multidisciplinary science and engineering research center, where talented scientists and engineers work together to answer the biggest questions facing humanity, from how to obtain affordable clean energy to how to protect ourselves and our environment. This training provided new science teaching standards for middle and high school science educators with methods that will help prepare their students for STEM-related careers. Specifically, the educators learned to teach students using evidence-based information.

Of significance were the partnerships between the Japan Atomic Energy Agency (JAEA) and various MS. With the Malaysian Nuclear Agency they organized a program called Nuclear Science and Technology for Secondary Schools, while Philippines education program supervisors and teachers were sent for NST training. This program included mini experiments involving teachers and students from chosen schools. A student essay writing competition has further attracted students and teachers, while others have experienced nuclear science experiments such as the “Let’s Measure Background Radiation using Mr. Gamma and Mini Cloud Chamber Experiment”.

6. Suggested enhancement for strategic partnerships

Strategic partnerships aim to support the development, transfer and/or implementation of best practices as well as the creation of joint initiatives that center on cooperation, peer learning and exchanges of experience at a national and international level. They target those wishing to:

- develop or reinforce networks
- increase their capacity to operate at multinational level
- share and discuss ideas, practices and methods, including the results of their activities, in a manner proportional to the aim and scope of the project.

Among the MS various countries had similar organizations involved in the implementation of NST education, such as the Ministry of Education, Ministry/ Department of Innovation Science and Technology, and various nuclear research institutes. However, the consensus among participating teachers was that the Ministry of Education should spearhead the planning, processes and implementation of NST into secondary school education programs as the custodian of national education. This will ensure of the sustainability of NST education, embedded into the education system, as well as making sure that all teachers under the ministry receive the correct training on NST-related topics, especially in terms of competency and skill. It will also establish a standardized teaching competency among all teachers involved in the delivery of the NST curriculum.

Table 4.
Suggestions for partnership activities by country.

Country	Suggestion for partnership activities
Indonesia	• Provide better dissemination in the flow of information about NST, for example, training, courses, competitions or Olympiads: IAEA → Through BATAN/BRIN → Collaborates with the Ministry of Education as the Ministry has access to all schools in Indonesia • Establish a NST-related competition for both junior and senior high school levels for both teachers and students at the national level in collaboration with BATAN/BRIN and the Ministry of Education
Malaysia	• Involve regulators such as the Atomic Energy Licensing Board (AELB) in working together with the Ministry of Education • Strengthen ties between the Ministry of Education and the Malaysian Nuclear Agency, with a greater focus on promoting programs relating to NST education • Develop partnerships between respective Ministries of Education from other countries to talk about best practice in NST education in each country
Oman	• Provide awareness to school administrators (in terms of appropriate NST facilities for teachers and students) • Establish national NST Olympiads as part of the scientific Olympiads conducted by the Department of Innovation and Scientific Olympiad in the Ministry of Education • Create national competitions that showcase and share projects and research

Philippines	• Involve other schools' divisions in the conduct of different training relating to NST education, especially in more remote areas
	• Link with the Curriculum and Instructions Development Section for possible integration of NST concepts and topics in the curriculum
	• Involve local government units/agencies such as waste management, national water resources
	• Link with universities to:
	  ▪ produce papers/journals, conduct action research
	  ▪ provide programs that involve students (exposure to NST education at a tertiary level)
	  ▪ provide NST education to education undergraduates in universities as a foundation for their own teaching

Lessons learned from past projects, for example the RAS0065 Project, have identified various key factors that need attention in the successful delivery of strategic partnerships in NST education:

- Know the needs of students, teachers, stakeholders, partners and community.
- Flexibility and adaptation are needed to adjust to find common ground and enhance movement towards success when obstacles are present.
- Teachers are the most influential partners as they take their new knowledge back to their classrooms and community, acting as ambassadors for opportunities in NST.
- When funding becomes an issue, find creative alternatives and partners that can support related interests.
- Understand the interests and motivations of participants and design strategies and activities around them.
- Consider enhancing and/or supporting existing efforts when there is no support for new activities.
- Utilize contracts and agreements when working with teachers to provide a clear understanding of expectations, deliverables and deadlines.
- Good works and success lead to more opportunities and more support.
- Publish successes and events to create awareness of effort and good works.

University education has an undeniable continuing role to play, especially in the field of NST. Current educational technology enables greater communication between universities and prospective students than ever before. However, universities could be under threat if they do not move rapidly in the digital world to ensure that a university degree remains the most desirable and credible qualification available. Collaboration between public and private universities can further enhance creativity in promoting NST as a field of expertise. This may potentially generate educators who are not only able to create interactive methods for delivering nuclear topics, but are also competent in formal matters. Active research and related publications could involve academics, teachers and students, creating STEM career paths in NST while also building human resources capacity.

One particular form of collaboration that was suggested was a “mentor-mentee” NST program where mentors come from academia while mentees are secondary school students and teachers. In an arrangement that could be described in terms of “shadowing”, secondary students and teachers could engage in internships or fellowships to better understand the NST topics that they are interested in and observed how they are being studied for use in the laboratory or research. Finally, academia should also be involved in the development, maintenance and revision of the NST module that has been created for secondary education.

7. Partnership with industry

Early adolescence is a period of active vocational development, during which young people consider their educational and career options, find part-time employment, choose which subjects to enroll in, and sometimes narrow the field of possible career choices. Previous studies have shown that career intentions for STEM correlate with general interest in STEM subjects and, as such, industry visits represent a unique opportunity for students to experience a previously undiscovered talent or interest for NST-related professions. In addition, the effect of extra-curricular learning opportunities, such as visits to industry workspaces, has been found to foster development in scientific learning, the development of self-efficacy, and even a sense of belonging to a local area.

STEM education needs to advance and develop as our society grows more technologically dependent in order to produce competent human resources for future socioeconomic development. This is definitely true in terms of the benefits of NST application in various fields such as human health and agriculture. Having partnerships with NST-related industrial sectors effectively ensures that learners are exposed to current and cutting-edge technologies while also acquiring practical experience. Exciting and innovative approaches to NST education will ensure that young learners are interested in joining the workforce of the future, particularly in NST-specific industries. At the same time, industry experts will be able to be engaged in developing educational topics to ensure that educational content is relevant and reflects the knowledge skills required for a particular profession or technology.

8. Dynamic situations in partnerships

In some countries, government institutions have dynamic structures, policies, targets and priorities. The IAEA cooperation program is based on the national needs and policies of each MS, and thus each country needs to be adaptive in anticipating change at the national level. A strong partnership strategy should be able to deal with change so that NST education programs can remain relevant over the long term with measurable impacts.

a National policy change

NST education program changes in terms of national policy may vary according to each country. Several MS have already altered both their curricula and educational policies after Project Counterparts involved education stakeholders and high-level decision-makers in developing NST introduction programs in schools. These Project Counterparts have been encouraging the emergence of support for curriculum policies in favor of nuclear topics so that NST education can be well structured and felt broadly across the education spectrum, and have thus been important in motivating national policy change.

However, national policy change can also occur in terms of alteration of priority targets, with the possibility that a NST education program is no longer a priority. This change carries the risk of causing a decline in national implementation of NST education.

In both cases, the importance of stakeholder interest evidence on the importance of NST education programs for schools as a bargaining tool cannot be understated. This evidence should be able to demonstrate a significant and measurable impact. Through evidence based on stakeholder interest, Project Counterparts can encourage favorable policies leading to the sustainability of NST education. They can also be a shield when national policy priorities begin to weaken. The IAEA periodically monitors and evaluates implementation programs, however each MS should have its own independent instrument gathering evidence that is more dynamic and focused on individual national needs. National evidence can take the form of quantitative targets and achievements, impact on educational needs, collaborative partnerships or milestones.

b Counterparts

When a change in Project Counterpart occurs it is vital to maintain the same level of understanding among the national team, whether this be program understanding, contribution to collaboration, or other technical knowledge. This is so that such a dynamic change in the structure of the national team will not have a long-term impact on NST education program implementation. Every country has a different team structure. However, an equal understanding and sense of belonging will aid a smooth transition of Project Counterpart.

Contents

Conclusion

"Coming together is a beginning, keeping together is progress and working together is success."

Henry Ford

A good school-based governance framework that is founded on strong partnerships is key to a successful and sustainable NST education system. NST education requires cross-agency participation from research institutions, education, industry and other stakeholders. The appropriate partnership strategy should encourage NST education programs that are measurable and implementable in the long term.

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Strategic partnership

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