WORKING DOCUMENT

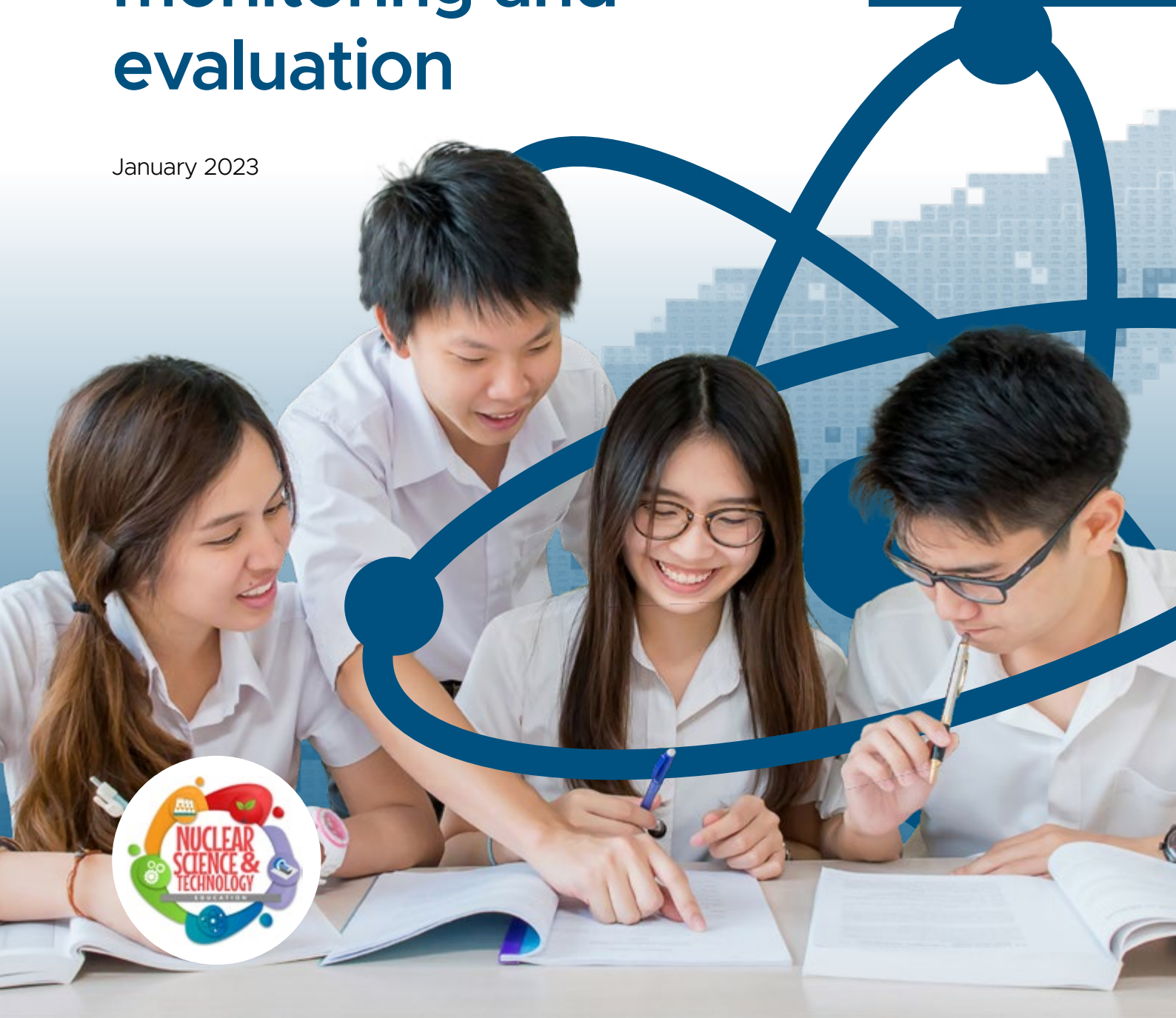
Guidebook series for introducing
Nuclear Science and Technology
in secondary education

GUIDEBOOK

5

Assessment, monitoring and evaluation

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 guidebook explains the monitoring and evaluation required to assess the knowledge, skills and values delivery of NST in secondary school education. This is in line with Sustainable Development Goal (SDG) 4 — to ensure that equitable and good-quality education is provided to all of the population and at all levels.

Disclaimer

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Contents

List of abbreviations

AELB	Atomic Energy Licensing Board
ANENT	Asian Network for Education in Nuclear Technology
ANSTO	Australian Nuclear Science and Technology Organization
Argonne	Argonne National Laboratory
BATAN	National Nuclear Energy Agency of Indonesia
BRIN	*Badan Riset dan Inovasi Nasional* National Research and Innovation Agency of Indonesia
COS-R	Classroom Observation Scale-Revised
COT	Classroom Observation of Teachers
DepEd	Department of Education
DOST	Department of Science and Technology
IAEA	International Atomic Energy Agency
INIS	International Nuclear Information System
KRAs	Key Result Areas
LFA	Logical Framework Approach
MoE	Ministry of Education
MOVs	Means of Verification
MS	Member State
NST	Nuclear Science and Technology
PBPPP	Integrated Assessment for Education Service Officers
PNRI	Philippine Nuclear Research Institute
PPST	Philippine Professional Standards for Teachers
RPMS	Results-based Performance Management System
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering and Mathematics
UN SDGs	United Nation's Sustainable Development Goals

1. Introduction

Appraising whether or not the goals of education are being met is an integral part of good education. It inspires teachers to ask these questions:

"Are students gaining the knowledge that they should be gaining? Is there a method to improve the subject's teaching so as to encourage better learning?"

Conducting assessment, monitoring and evaluation are ways of looking at the particular needs of each student and the support they require to access school programs and participate in the curriculum. At the same time, information from such appraisals can provide supportive and developmental processes that ensure teachers have the skills and support they need to carry out their role effectively.

Assessment generally refers to the gathering of various data from multiple sources to evaluate a student's understanding and learning. This information, when analyzed and put into perspective, aids in determining the level of development and challenges of each student. It can also help close the gap between greater student performance and content retention by providing more insight into the causes of any issues that students encounter.

Meanwhile, monitoring and evaluation combine as a mechanism of quality assurance in determining the quality of an education system. One of the roles of a school is to groom future human resources and meet the demands of the country, assessing what knowledge, skills and values are needed to participate effectively in society. An economically viable nation is the result of its educated population.

Monitoring is defined as the systematic collection, analysis and use of data to track a program's progress towards its goals and to inform management choices. Processes, such as when and where activities occur, who provides them, and how many people or entities they reach, are usually the subject of monitoring. Evaluation on the other hand, is a systematic activity that is used to draw conclusions regarding the relevance and effectiveness of a project or program. The primary difference between monitoring and evaluation is that while monitoring is a continuous activity, performed at the operation or teaching level, evaluation is a periodic activity, performed at the school management level.

Generally, it is recommended the educational outcomes are measured against short, medium and long-term goals. This may include the design of realistically established deliverables for monitoring the implementation of a program and for tracking outcomes. Variables that can be assessed include:

- the number of teachers or students participating in related activities
- their views on NST before, during and after participation
- the evolution of their educational and career plans.

An assessment using these variables this will be able to outline the deliverables and/or expectations of NST education for secondary school students as well as highlighting the successes, constraints and achievements of the education implementation.

For the purpose of discussion, monitoring and evaluation has been divided into three (3) categories which are:

- monitoring and evaluation of student performance
- monitoring and evaluation of teachers
- monitoring and evaluation of overall NST topic implementation for secondary education.

2. Monitoring and evaluation of student performance

This is a crucial component and should be carried out in a way that allows for adequate results while also encouraging student interest and motivation to pursue tertiary study in NST. Assessment allows both teachers and students to monitor progress towards achieving learning objectives and can be approached in a variety of ways.

Generally, there are two (2) types of assessment:

Formative

This refers to a range of approaches used by teachers to monitor student comprehension, learning requirements and academic achievement in the process of a lesson, unit or subject. Formative assessment uses tools that identify misconceptions, struggles and learning gaps along the way, while also analyzing how to close those gaps. It includes effective tools for helping to shape learning and can even bolster student ability to take ownership of their learning, when they understand that the goal is to improve learning, not to apply final marks (Trumbull & Lash, 2013). It can include students assessing themselves, their peers, or even their instructor, through writing, quizzes, conversation and more. Formative assessment occurs throughout a class or course, and seeks to improve student achievement of learning objectives through approaches that can support specific student needs (Theall & Franklin, 2010, p. 151).

Summative

This refers to assessments that evaluate student learning, knowledge, proficiency or success at the conclusion of an instructional period, like a unit, course or program. Summative assessments are almost always formally graded and often heavily weighted (although they do not need to be). They can be used to great effect in alignment with formative assessment, and instructors can consider a variety of ways to combine these approaches.

Alternative approaches include output-based assessment through appraising portfolios or performance-based assessment. These monitoring and evaluation approaches need to establish a measurable time and level for each goal. For STEM-related subjects, school-based monitoring and evaluation should cover content knowledge and scientific skills, as well as scientific and moral values.

Monitoring and evaluation guidelines should be made available, and teachers free to utilize the most appropriate methods to assess the performance of their own students. Table 1 documents some of the monitoring and evaluation that has been used for NST secondary education.

Table 1.

Examples of monitoring and evaluation based on formative and summative assessments for students

Monitoring and evaluation methods	
Formative assessment	**Summative assessment**
• In-class discussion and questions • Class participation and interaction (observation — class activities) • The use of smartphone applications and the Internet in classroom management, such as: teacher kit — Classroom Timer Pro • Clicker questions • Positive reinforcement • Home worksheets • Class worksheets • Activity sheets • Interviews • Problem-based learning (PBL) • Laboratory work • Short quizzes • Journal entries • Student reflections • Surveys	• Instructor-created exams • Standardized tests • Final practical reports • Projects • Rubric assessment • End-of-school examination • National Achievement Test • Large Scale Test — PISA (Program for International Student Assessment) • Post test rubric assessment • Final essay • Final presentation

Both forms of assessment (formative and summative) can vary across a range of dimensions including:

- informal v formal
- immediate feedback v delayed feedback
- curriculum-embedded v stand-alone
- spontaneous v planned
- individual v group
- verbal v nonverbal
- oral v written
- graded/scored v ungraded/unscored
- open-ended response v closed/constrained response
- teacher initiated/controlled v student initiated/controlled
- teacher and student(s) v peers
- process oriented v task/product oriented
- brief v extended
- scaffolded (teacher supported) v independently performed.

An example that a participant from Indonesia was able to share was a student assessment form on the topic of nuclear technology (see Tables 2 and 3). Table 2 is an example of a worksheet and it's accompanying rubric, while Table 3 is an example of an evaluation of a student written test that is currently being used in Indonesia.

Student worksheets are printed instructional material guidelines supplied to students by their teachers that supplement or support their learning activity. They enable students to carry out activities to improve their comprehension.

Table 2.
Student worksheet instructions and rubric — example from Indonesia

STUDENT WORKSHEET

Subject : Physic
Class/Semester : XII/2
Material : Nuclear Technology

Basic Competence
Analyze the characteristics of the atomic nucleus, radioactivity, use, impact, and protection in everyday life

Indicator
Summarize the nuclear fission reaction in a nuclear reactor

Learning Material

Factual
- Nagasaki and Hiroshima atomic bombs
- Nuclear reactor accident in Japan

Concept
- Fission reaction is the division of heavy nuclei into light nuclei accompanied by the release of energy

Principle
- Uncontrolled fission chain reaction is very dangerous for life
- Controlled fission chain reactions can be used for alternative energy

Study Guide
1. Pay attention to every video that is shown
2. Record every information obtained from video shows
3. Discussion with friends from the information obtained in the video show
4. Do the tasks below

Task:
1. Explain the fission reaction!
2. What happens when the fission reaction is out of control?
3. Does Indonesia have a nuclear reactor? Mention
4. What is the difference between a research nuclear reactor and a power nuclear reactor?
5. Compare the advantages of PLTN with PLTA?!

STUDENT WORKSHEET RUBRIC

Subject : Physic
Class/Semester : XII/2
Material : Nuclear Technology

Provide a score in the columns according to the results of observations

No.	Name	Video Observation Activities	Discussion Activities	Task Activities	Total Score

Student Worksheet Assessment Rubric

Score	Make Video Observations
1	Just keep quiet, do not observe and do not take notes
2	Make observations but do not focus and do not take notes
3	Observing and focusing but not taking notes
4	Make observations with focus and take notes

Score	Discussion Activities
1	Remain silent
2	Discuss but most of the time remain silent
3	Discussing but not giving much opinion
4	Discuss and give a lot of opinions

Score	Answer	Score
1	The reaction of breaking heavy nuclei into light nuclei while producing heat energy	1
2	Very dangerous and can produce a powerful explosion like an atomic bomb	1
3	Yes, Kartini research reactor of the TRIGA type is self-sufficient	2
4	Research reactors are only for generating electricity	1
5	In terms of output, it can produce enormous amount of electrical energy and less fuel	1
6	According to their respective opinions but explained the reason	2
	Total Score	8

Final Score = $\frac{\text{Total Score}}{8} \times 100$ | **Final Score**

Table 3.

A rubric assessment for a written test

Written Test Sheet: Post Test

No.	Indicator	Question item	Rubric assessment	Score
1.	**Conclude a physical reaction** C4-K4	Based on the video showed during learning, analyze the reactions that occur in nuclear reactors and atomic bombs?	Fission reaction is a reaction that splits heavy atomic nuclei into light atomic nuclei while producing heat energy	1
			Uncontrolled fission chain reaction is very dangerous because it produces uncontrolled and dangerous energy and that happens in atomic bombs	1
			Controlled fission chain reactions are used in nuclear reactors to produce energy for life	1
			Total score	**3**
2.	**Analyzing work processes in nuclear reactors** C4-K4	From the videos shown during the learning, analyze how the nuclear reactor works? Chart the parts and functions of a nuclear reactor? Compare Indonesia with countries that use nuclear power plants, does Indonesia need to build nuclear power plants in the future?	Nuclear reactors work using the principle of a controlled and maintained fission chain reaction. Every time there is a breakdown of heavy cores into light nuclei that produce heat, energy can be controlled. This heat energy will turn the turbine and produce electrical energy.	2
			Basic component: 1. Fuel is uranium U-225 2. Moderator to slow the motion of neutrons so that the reaction takes place perfectly, generally water is used as a moderator 3. Control rods that are generally used are either boron or cadmium. In a controlled reaction, one free neutron is required. Because the previous reaction produced an average of 2-3 free neutrons, the unwanted neutrons must be absorbed by Boron or Cadmium. The control rod functions to control the number of neutron populations. 4. Concrete shields serve to withstand gamma ray radiation and neutrons so as not to harm the environment.	4
			Total score	**6**

Final Score = $\frac{\text{Total Score}}{8} \times 100$ | **Final Score**

Written tests are primarily used to assess knowledge-based learning outcomes.
They may, however, be used to assess attitude or skills, as they are a part of the student's overall evaluation strategy.

Moreover, the Philippines shared an example of a learners instructional chart for Nuclear Science and Technology Assessment, Monitoring and Evaluation (NST-AME).

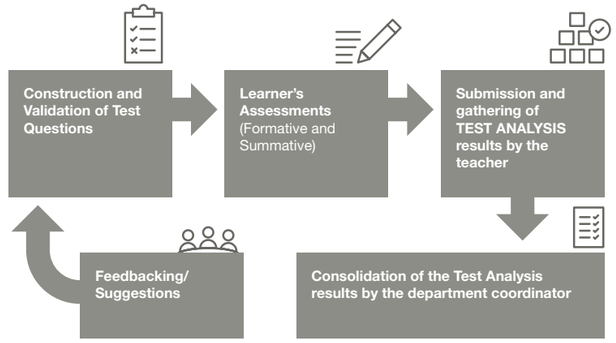


Figure 1.

Learners Instructional Chart for NST-AME

The Philippines also shared an example of a teachers instructional chart for Nuclear Science and Technology Assessment, Monitoring and Evaluation (NST-AME).

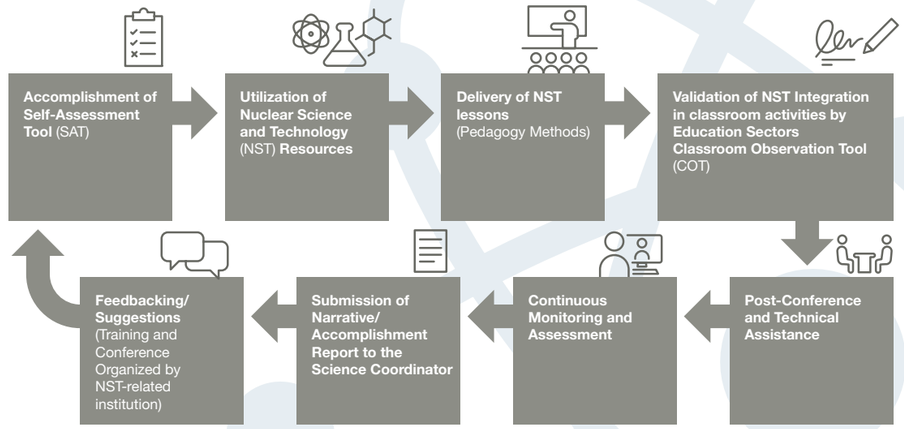


Figure 2.

Teachers Instructional Chart for NST-AME

3. Monitoring and evaluation of teachers

Monitoring and evaluation of teachers play a critical and important role in the improvement of the education sector. Previous research has shown that teacher quality is positively linked to student learning, hence having highly qualified, effective instructors in the school system is important.

During a meeting on the Development of a Model Curriculum for Secondary Level Education held in May 2022, the winning and finalist teachers of the 2021 Secondary NST Education Competition (representing four (4) MS — Philippines, Malaysia, Indonesia and Oman) shared their experience in this area.

One approach that is commonly taken is Classroom Observation of Teachers (COT), based on the Results-based Performance Management System (RPMS) of the Philippine Professional Standards for Teachers (PPST). Various RPMS-PPST Tools observe a teacher's performance in their classroom or learning environment and document them in action, using Key Result Areas (KRAs) as a framework to determine teacher roles and responsibilities. Teachers are required to:

- apply knowledge of content within and across curriculum teaching areas
- use a range of teaching strategies that enhance learner achievement in literacy and numeracy skills
- manage the classroom structure (learning environment and diversity of learners) to engage learners, individually or in groups, in meaningful exploration, discovery and hands-on activities within a range of physical learning environments
- manage learner behavior constructively by applying positive and non-violent discipline to ensure learning-focused environments
- use differentiated, developmentally appropriate learning experiences to address learners' gender, needs, strengths, interests and experiences
- plan, manage and implement developmentally sequenced teaching and learning processes to meet curriculum requirements and varied teaching contexts.

In short, classroom observations are a quantitative technique for capturing and measuring teacher behavior and mastery at different career stages. The frequency of performing observation depends on school scheduling and can be done at regular intervals, for example, on a quarterly basis. An example of the Classroom Observation Scale is shown in Table 4.

Table 4.

The Classroom Observation Scale-Revised (COS-R) (Source: Van Tassel-Baska, 2012)

Directions: Please employ the following scale as you rate each of the checklist items. Rate each item according to how well the teacher's characteristic or behavior was demonstratedduring the observed instructional activity. Each item is judged on an individual, self-contained basis, regardless of its relationship to an overall set of behaviors relevant to the cluster heading.

3 = Effective	2 = Somewhat Effective	1 = Ineffective	N/O = Not Observed
The teacher evidenced careful planning and classroom flexibility in implementation of the behavior, eliciting many appropriate student responses. The teacher was clear, and sustained focus on the purposes of learning.	The teacher evidenced some planning and/or classroom flexibility in implementation of the behavior, eliciting some appropriate student responses. The teacher was sometimes clear and focused on the purposes of learning.	The teacher evidenced little or no planning and/ or classroom flexibility in implementation of the behavior, eliciting minimal appropriate student responses. The teacher was unclear and unfocused regarding the purpose of learning.	The listed behavior was not demonstrated during the time of observation. (NOTE: There must be an obvious attempt made for the certain behaviour to be rated "ineffective" insterad of "not observed".

General Teaching Behaviors				
Curriculum Planning and Delivery	**3**	**2**	**1**	**N/O**
The teacher…				
1. set high expectations for student performance				
2. incorporated activities for students to apply new knowledge				
3. engageed students in planning, monitoring or assessing their learning				
4. encouraged students to express their thoughts				
5. had students reflect on what they had learned				
Comments:				

Differentiated Teaching Behaviors				
Accommodations for Individual Differences	**3**	**2**	**1**	**N/O**
The teacher…				
6. provided opportunities for independent or group learning to promote depth in understanding content				
7. accommodated individual or subgroup differences (eg. through individual conferencing, student or teacher choice in material selection and task assignments)				
8. encouraged multiple interpretations of events and situations				
9. allowed students to discover key ideas individually through structured activities and/or questions				
Comments::				

Problem Solving	**3**	**2**	**1**	**N/O**
The teacher…				
10. employed brainstorming techniques				
11. engaged studetns in problem identification and definition				
12. engaged students in solution-finding activities and comprehensive solution articulation				
Comments::				

Critical Thinking Strategies	**3**	**2**	**1**	**N/O**
The teacher…				
13. encouraged students to judge or evaluate situations, problems, or issues				
14. engaged students in comparing and contrasting ideas (eg. analyse generated ideas)				
15. provided opportunities for students to generalize from concrete data or information to the abstract				
16. encouraged student synthesis or summary of information within or across disciplines				
Comments:				

Critical Thinking Strategies	**3**	**2**	**1**	**N/O**
The teacher…				
17. solicited many diverse thoughts about issues or ideas				
18. engaged students in the exploration of diverse points of view to reframe ideas				
19. encouraged students to demonstrate open-mindedness and tolerance of imaginative, sometimes playful solutions to problems				
20. provided opportunities for students to develop and elaborate on their ideas				
Comments::				

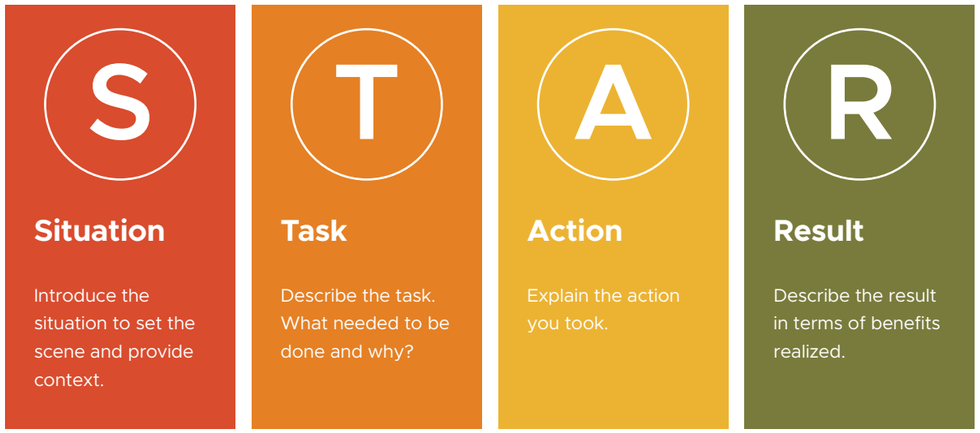
Research Strategies	**3**	**2**	**1**	**N/O**
(It is atypical for these to be observed in one session. Some teachers, however, may use Items #21-25 within a single period to illustrate the full research process to students. Please note those observations in the comments section)				
The teacher…				
21. required students to gather evidence from multiple sources through research based techniques (eg. print, non-print, internet, self-investigation via surveys, interviews, etc)				
22. provided opportunities for students to analyze data and represent it in appropriate charts, graphs, or tables				
23. asked questions to assist students in making inferences from data and drawing conclusions				
24. encouraged students to determine implications and consequences of findings				
25. provided time for students to communicate research study findings to relevant audiences in a formal report and/or presentation				
Comments::				

For detailed viewing, please refer to the Asian Network for Education in Nuclear Technology (ANENT) website at www.anentweb.org

Another method that has been used in the Philippines is the "means of verification" (MOV) method and is part of eighteen (18) indicators from the RPMS-PPST objectives developed by DepEd. The Professional Online Community of Teachers and for Teachers has compiled an overview document and made it readily for teachers through a specific website called www.teacherph.com.

Yet another approach to teacher monitoring and evaluation is a behavioral interview session. One technique that has been suggest being used in such interview is the STAR Technique (Situation, Teacher action, Action of the learners, Results), which involves competency-focused questions (see Figure 3). Using these strategies, teachers are able to demonstrate problem-solving abilities, analytical abilities, creativity, perseverance through hardship, writing abilities, presenting abilities, teamwork orientation, persuasiveness, and quantitative abilities.

STAR Interview Method



The STAR Method is a tool for answering tough behavioral interview questions.

Figure 3.
STAR Interview Method

Other than those mentioned above, the more routine approaches that have been used for monitoring and evaluation are represented in Table 5.

Table 5.
Examples of monitoring and evaluation of teachers

Monitoring and evaluation methods
• Bi-annual evaluation by senior teachers, headmasters and superintendents
• Teachers who don't meet requirements to undergo further evaluation
• Assessment by two (2) senior individuals, using a rubric (Integrated Assessment for Education Service Officers (PBPPP))
• COT (Ref: Appendix-3C-COT-RPMS-Rating-Sheet-for-T-I-III-for-SY-2021-2022-in-the-time-of-COVID-19.pdf (teacherph.com))
• Peer-to-peer evaluation

Oman also has its own methodology, as shown in Table 6.

Table 6.
Supervisory visit form for assessing Subject/Field Teacher — example from Oman

استمارة الزيارة الإشرافية لمعلم مادة / مجال
Supervisory visit form for subject/field teacher

المدرسة **School name**	اسم المعلم **Teacher name**	عنوان الدرس **Title of lesson**	اليوم **Today**	التاريخ **Date**	الحصة **Class time**

م	العنصر Element of evaluation	دليل الاجادة Proof of proficiency	دليل التطوير Proof of development		
1	اعداد خطة سنوية ويوميةمتكاملة Preparing an integrated annual and daily plan				
2	سلامة المادة العلمية المقدمة والتمكن منها Accuracy of the scientific material presented to students				
3	التسلسل المنطقي للموقف التعليمي The logical sequence of the educational situation				
4	استخدام لغة عربية سليمة Use proper Arabic language				
5	اثارة دافعية الطلبة للتعلم Motivating students to learn				
6	فاعلية الأدارة الصفية The effectiveness of classroom management				
7	فاعلية استراتيجية التدريس المستخدمة The effectiveness of the teaching strategy used				
8	توظيف مصادر التعلم والمختبرات وتقنيات التعليم الفاعلة Employment of effective learning resources, laboratories and teaching techniques				
9	اكساب الطلبة المعارف والمهارات وتوظيفها Providing Students with knowledge and skills and employing them				
10	توجيه الطلبة للتعلم الذاتي Guiding students for self-learning				
11	تنمية الأتجاهات الايجابية والقيم Developing positive attitudes and values				
12	توظيف أدوات التقويم المناسبة وتوثيقها Employing appropriate evaluation tools and documenting them				
13	التنوع في طرح الأسئلة وفاعليتها Diversity in asking questions and their effectiveness				
14	توظيف نتائج ادوات التقويم في تطوير اداء الطلبة Employing the results of assessment tools in developing students' performance				
15	تنفيذ خطط علاجية واثرانية فاعلة للطلبة Implementation of Effective treatment and enrichment plans for students				
16	تقييم وتقويم اداءه ذاتيا Self-assessment and evaluation of performance				
	Notes				
	Recommendations				

Elements that are included in the checklist include the preparation of daily and annual lesson plans, the reliability of reference materials used, teaching strategies, the use of other learning resources and the appropriateness of the type of student evaluation. The teacher is also evaluated for their use of proper Arabic language, inner positive values and how they motivate students to learn.

Meanwhile, the Malaysian Education Quality Standard Second Wave largely emphasizes a teacher's role as a facilitator, while the pupils are active learners. Six (6) aspects of teaching and learning are given prominence to ensure effective teaching and learning is feasible in a conducive and non-threatening environment.

The six (6) aspects pertaining to the crucial roles of the teacher and the pupils are described as follows:

A. Teacher as the planner

Critical criteria:
As the planner, the teacher needs to ensure that all participants in the classroom are set for the teaching and learning process. To meet this criterion, the teacher should prepare daily lesson plans with specific and measurable objectives as well as designing appropriate learning activities and materials that cater to pupils' various levels of ability. The teacher should also plan assessment activities to gauge pupils' understanding and mastery of knowledge and skills derived from the lesson delivered.

B. Teacher as the controller

Critical criteria:
As the controller, the teacher is responsible for ensuring the smooth running and delivery of the teaching and learning process in the classroom. The teacher should control the teaching and learning process by:

i. utilizing and optimizing the time allocated with meaningful and fun-learning activities corresponding to the various levels of pupil ability
ii. providing ample opportunities for the entire class to participate actively in a conducive learning climate
iii. continuously monitoring pupils' communication and behavior throughout the teaching and learning process.

C. Teacher as the guide

Critical criteria:
As the guide, the teacher is responsible for leading the pupils to productively master the knowledge, skills and values being imparted, based on the learning objective(s). The teacher should constructively guide the pupils to understand and master the content of the lesson through meaningful and fun learning activities which cater to the pupils' various levels of ability. In addition, the teacher should also strive to get the pupils involved in the pursuit of decision-making and problem-solving. This is in compliance with the current implementation of 21st century pedagogical skills which aim to further enhance the pupils' learning through stimulating teaching and learning processes.

D. Teacher as the motivator

Critical criteria:
As the motivator, the teacher is accountable for enhancing the pupils' self-esteem and soft skills. The teacher should continuously show concern and offer constructive praise and positive encouragement as a reward throughout the teaching and learning process, with the aim of further developing pupils' confidence.

E. Teacher as the evaluator

Critical criteria:
As the evaluator, the teacher is responsible for assessing the pupils' performance and level of mastery pertaining to the lesson delivered. The teacher should employ various methods of assessment aimed at measuring pupil understanding and performance throughout the teaching and learning process. The findings should then be utilized by the teacher to conduct any necessary remedial or enrichment activities to further enhance the pupils' comprehension of the lesson.

F. Pupils as active learners

Critical criteria:
Pupils are expected to actively participate in the teaching and learning process in order to master the stipulated skills and knowledge, as well as to internalize the positive values being imparted in the lesson. Pupils should actively participate by responding consistently to the lesson content as well as by communicating with one and another throughout the teaching and learning process. Pupils should also be continuously encouraged to ask questions and stimulated to develop their critical and creative thinking pertaining to the subject matter.

Overall, it was interesting to note the variations in assessment methods used by teachers, either formal or informal, as presented by their school representatives. The findings of these assessments now need to be communicated professionally back to the teachers themselves to enable future improvement.

4. Monitoring and evaluation on overall NST topic implementation for secondary education

One of the references suggested in relation to monitoring and evaluating overall NST education implementation is a document entitled "Comprehensive Professional Learning System: A Workbook for States and Districts". This publication elaborates on the infrastructure required to develop the individual, school, team and school system capacities needed to ensure success for all educators and their students — essentially outlining the components needed for professional learning to meet the demands of educators and their students. There are at least six core components:

- a vision of a professional learning system that is part of the education system
- a definition of professional learning
- standards for professional learning to guide quality
- stakeholder roles and responsibilities defined and articulated
- ongoing assessment and evaluation
- resources — including staff, time, funds and facilities.

Other approaches to monitoring and evaluation involves assessment by way of the Content, Context and Process (CCP) approach. The use of CCP as an overarching approach to evaluation allows such questions as: what is being measured, by whom and for what purpose? (see Figure 4). The interaction and linkages between context, content and process allows for the procedure of evaluation to be explored in multiple ways

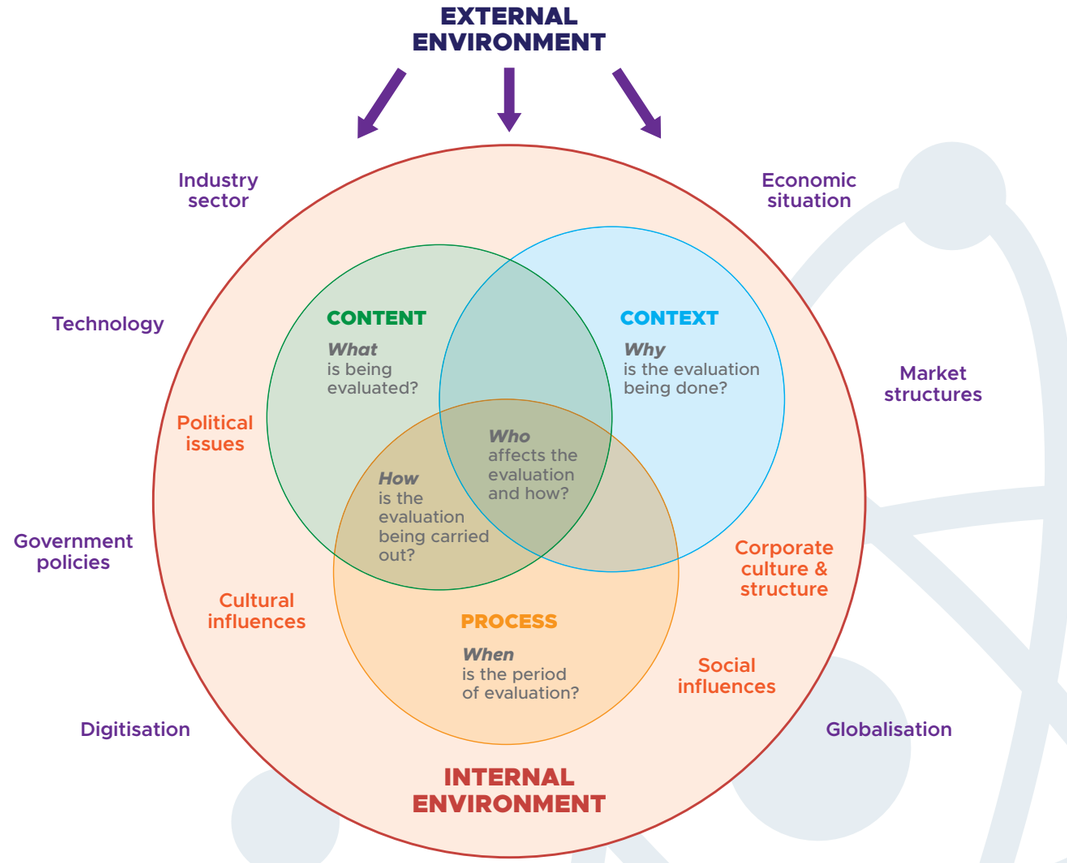


Figure 4.
The Content, Context and Process Framework.

Specifically in the field of education, CCP can be further elaborated:

CONTENT

- addresses educator learning outcomes
- learning experience matches the students' grade level and content area
- content reflects current research and best practice
- content reflects cultural awareness and learner diversity.

CONTEXT

- leadership
- environment
- culture
- data

PROCESS

- content reflects cultural awareness and learner diversity
- facilitation of learning
- collaborative learning opportunities
- reflection on student work
- linkage of content to practical application (implementation)
- suggestions for the extension of learning.

Another evaluation method that MS can used is the Logical Framework Approach (LFA) adopted by the Technical Cooperation Programme, IAEA, to achieve high quality project standards (see Figure 5). The LFA is an analytical process and set of tools for managing the completeness of a project and is based on the areas of planning, implementation, monitoring and evaluation. It is used to best advantage in participatory processes involving all relevant stakeholders in all phases.

The LFA Methodology

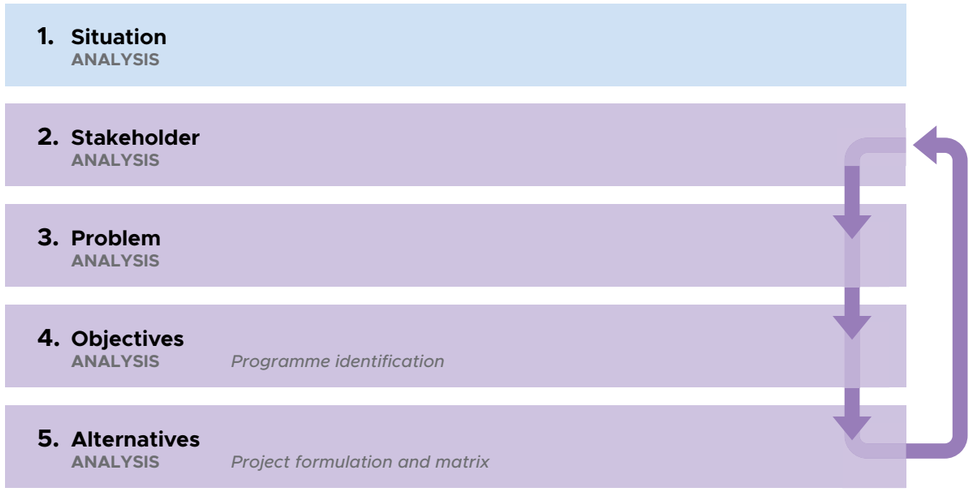
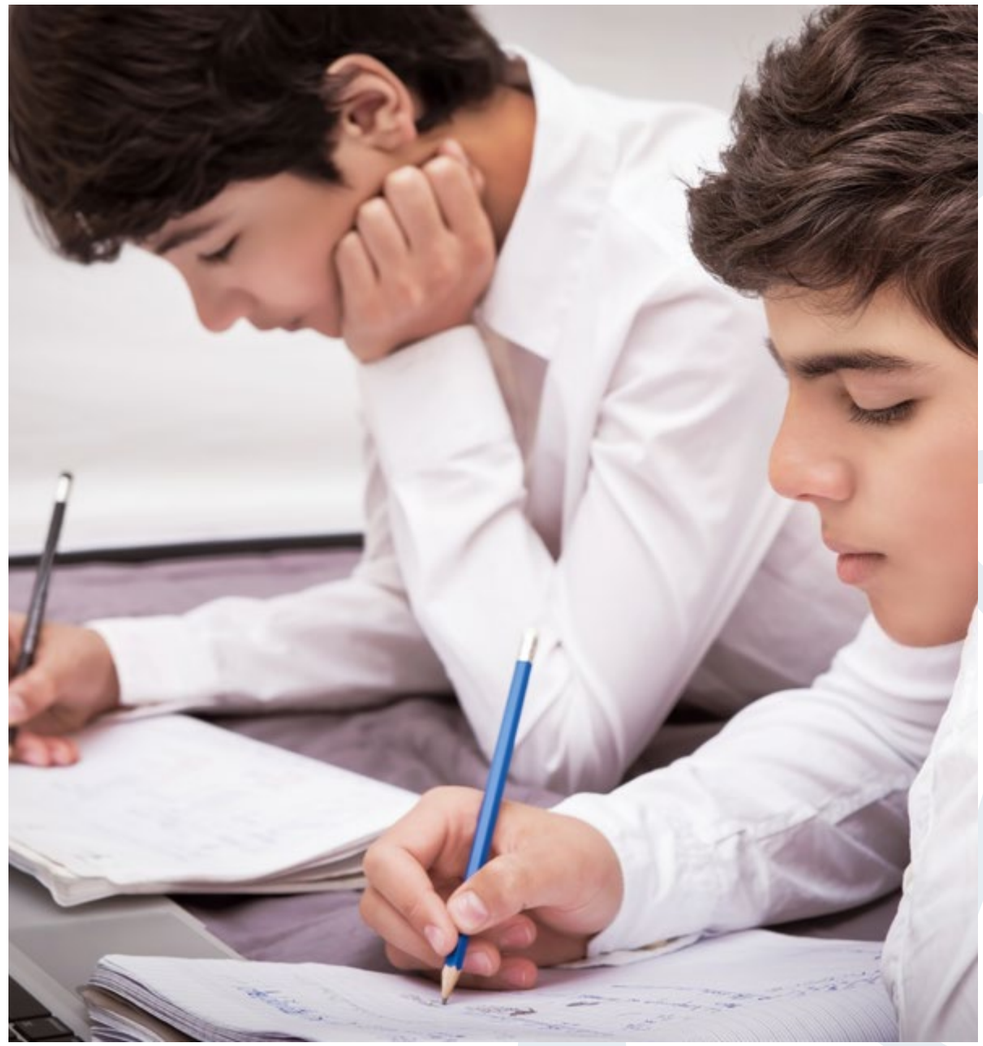


Figure 5.
The Logical Framework Approach (LFA)

The LFA basically has five (5) phases, which starts with performing a situational analysis to understand the project to be deveoped, and thus identifying factors to design a relevant and effective strategy, while also considering the related constraints. As the implementation of NST in secondary education can be a dynamic process, it requires constant "environmental scanning", to determine any necessary changes. The next phase involves anaylzing the relevant stakeholders who are needed and determining how they can influence the overall project. This includes developing stakeholder engagement as covered in Guidebook 1 of this series. Phases 3 to 5 relate to problem analysis, objective analysis and alternative analysis respectively.

The LFA is beneficial in the sense that it creates a dialogue with the stakeholders, expands owernership, clarifies objectives and is flexible. To better understand the LFA, its purpose and benefits, IAEA has a self-directed course that can be enrolled in via: www.iaea.org/online-learning/courses/478/logical-framework-approach-lfa



5. Suggestions for improving monitoring and evaluation

The winning and finalist teachers of the 2021 Secondary NST Education Competition have below provided some suggestions on improvements to the monitoring and evaluation of their own education systems as specific to NST topics (see Table 7).

Table 7: Suggestions to on how to improve existing monitoring and evaluation

Country	Co-curricular activities
Indonesia	• Create a lab work worksheet specific to NST
Malaysia	• Review NST the curriculum once every five (5) years — strategic partnerships are important here • Develop a NST-specific evaluation matrix to evaluate students' understanding and interest when doing activities like PBL
Oman	• For student evaluations: rely on practical activities, projects, practical research and students' own presentations • Assess the effectiveness of modern methods and strategies that teachers follow in teaching NST and provide workshops and courses to develop teacher and student performance
Philippines	• Create NST-specific evaluation tools for teachers and students • Use journal/Science Interactive notebook

6. Capacity building for human resources in NST

Teachers and school leaders are central to the learning process in schools. Pupils are ultimately dependent for their competence development on the expertise, energy, inspiration and imagination of the adults to whom they are entrusted. Teachers can be motivated by this privileged responsibility, but it is not an easy challenge, and societal and governmental expectations are demanding.

The personal and collective identities that teachers and school leaders form are also critical. If teachers and school leaders feel trusted and respected, and feel fully integrated into the wider education system, they may be more motivated to collaborate and improve that system, at a local level, and potentially beyond.

In any profession, capacity building is valuable as it minimizes an over-reliance on outside experts as sources of knowledge, resources and solutions to matters related to education. Capacity building is the process of developing and strengthening the skills, instincts, abilities, processes and resources that organizations and communities need to survive, adapt and thrive in a fast-changing world. It fosters a sense of ownership and empowerment, so that educators gain greater control in shaping their careers and the future generation for the benefit of the nation.

Within the education system in the Philippines, there is a program for K–12 teachers and students that has the aim of supporting, strengthening, and sustaining NST education. It does this by providing opportunities to promote the peaceful uses and applications of nuclear science and technology while enriching teacher and student knowledge, skills, and experiences in science.

There are courses specifically for the teachers, provided through a collaborative effort and jointly organized by the Philippine Nuclear Research Institute (PNRI), Department of Education, and trained teachers (see Figure 6).

A.

TEACHER TRAINING ACTIVITIES

- **Mode: Face-to-face and virtual**
- **Organised by:**
  Philippine Nuclear Research Institute
  Department of Education
  Trained Teachers

B.

TRAINING COURSES

- **Course on Basic Neutron Science** (CBNS)
  Training hours: 40 hours
- **Course on Nuclear Technology** (CNT)
  Training hours: 160 hours
- **Curie's Class: Nuclear Science for High School Teachers** (CURIE)
  Training hours: 40 hours
- **Follow up Training Course-Environmental Radioactivity Monitoring** (FTC-ERM)
  Training hours: 40 hours
- **Follow up Training Course-Nuclear Radiation Emergency Preparedness and Response** (FTC-NREPR)
  Training hours: 40 hours
- **Follow up Training Course-Reactor Engineering** (FTC-RE)
  Training hours: 80 hours
- **Seminar on Nuclear Science for Teachers** (SNST)
  Training hours: 160 hours

Figure 6.
Examples of teacher training activities (a) and courses (b) that teachers have attended in the Philippines

Regular curriculum review needs to be conducted, for example, every five (5) years, as is routinely done in tertiary education. This is so that the curriculum can be enhanced to remain relevant and up-to-date with current knowledge. It can be done using existing tools or curricula. Examples of curriculum review undertaken in the Philippines are:

RBEC-Revised Education Curriculum (2002–2010)

K–12 Curriculum (2010–2020)

MELCs Most Essential Learning Competencies (2020 until today)
this is the intended curriculum used in the Philippines during the pandemic

7. Competency mapping for teachers

There is a set of skills, knowledge, and behaviors that are frequently utilized to improve performance so that a person has the ability to perform a task well. Competency is when a person's talents, ability, and knowledge combine to make up a skill that becomes ingrained in the person, allowing them to accomplish a practical act in a particular field of work. This is also known as professional competency. A teachers' technical skills can incorporate a variety of elements in a variety of areas such as: pedagogy (teaching methods), culture, communication, personality, intellect, etc. — all of which are required for effective teaching.

Teachers are constantly being evaluated on their professional skill. In the Philippines, for example, first and foremost it is necessary to pass a specific licencing exam. This is required for everyone aspiring to teach in the Philippines public school system. On regular basis, teachers' competence is also assessed in the Philippines using the PPST, a new framework adapted from the previous paradigm, the National Competency-Based Teacher Standards (NCBTS), and mandated by the Department of Education.

The evaluation covers:

i. effective development and assessment of different thinking skills	**ii.** adoption of new ideas with regard to teaching methods	**iii.** effective classroom management which allows proper communication between teachers and their students
i. integration of ICT in teaching	**ii.** improved research skills	**iii.** skill in carrying out academic evaluation

There seven (7) domains in which teachers are required to be effective in 21st century Philippines (see Table 4).

Table 4: Teacher domain requirements

Domain	Name	Co-curricular activities
1	**Content knowledge and pedagogy**	i. Content knowledge and its application within and across curriculum areas ii. Research-based knowledge and principles of teaching and learning iii. Positive use of ICT iv. Strategies for promoting literacy and numeracy v. Strategies for developing critical and creative thinking, as well as other higher-order thinking skills vi. Mother Tongue, Filipino and English in teaching and learning vii. Classroom communication strategies
2	**Learning environment**	i. Learner safety and security ii. Fair learning environment iii. Management of classroom structure and activities iv. Support for learner participation v. Promotion of purposive learning vi. Management of learner behavior
3	**Diversity of learners**	Understanding: i. learners' gender, needs, strengths, interests and experiences ii. learners' linguistic, cultural, socio-economic and religious backgrounds iii. learners with disabilities, giftedness and talents iv. learners in difficult circumstances v. learners from indigenous groups
4	**Curriculum and planning**	i. Planning and management of the teaching and learning process ii. Learning outcomes aligned with learning competencies iii. Relevance and responsiveness of learning programs iv. Professional collaboration to enrich teaching practice v. Teaching and learning resources including ICT
5	**Assessment and reporting**	i. Design, selection, organization and utilization of assessment strategies ii. Monitoring and evaluation of learner progress and achievement iii. Feedback to improve learning iv. Communication of learner needs, progress and achievement to key stakeholders v. Use of assessment data to enhance teaching and learning practices and programs
6	**Community linkages and professional engagement**	i. Establishment of learning environments that are responsive to community contexts ii. Engagement of parents and the wider school community in the educative process iii. Professional ethics iv. School policies and procedures
7	**Personal growth and professional development**	i. Philosophy of teaching ii. Dignity of teaching as a profession iii. Professional links with colleagues iv. Professional reflection and learning to improve practice v. Professional development goals

Malaysia has also acknowledged that the development of science and technology has taken place very quickly in the era of industrial revolution 4.0. Therefore, the education system needs to be adaptable to such changes. As a result, in terms of teacher competency, Malaysia demonstrates a more or less similar evaluation to that of the Philippines.

The Malaysian Teacher Standards outlined by the Ministry of Education Malaysia (Teacher Education Division, 2009) include:

- Personal characteristics
- Curriculum planning,
- Evaluation and reporting
- Pedagogy
- Professional Information and communications technology
- School management and development
- Overall: teacher competence with regard to 21st century skills
  - various literacies
  - learning and innovation
  - information media and technology
  - life skills and careers.

Other competencies are based on lesson planning, computer skills, English language proficiency and also collaborative effort with peer colleagues.

In terms of specific courses on NST-related topics, Australian Nuclear Science and Technology Organization (ANSTO) runs programs for teacher professional development that are approved by the Australian Education Standards Authority. The courses provide reading material and relevant references that can be accessed via — www.ansto.gov.au/education/teachers/teacher-professional-development-courses These ANSTO courses also aim to increase teacher comprehension with regard to the advantages and challenges associated with the manufacture of nuclear medicines.

Competency in teaching skills and knowledge with regard to NST education will also motivate the teachers. In particular, it is likely to shape teacher interest in pursuing higher education, especially in relation to NST, as a form of teacher continuous professional development. This supports the concept of lifelong learning. It recognizes that humans have a natural drive to explore, learn and grow, and encourages us to improve our own quality of life and sense of self-worth by paying attention to the ideas and goals that inspire us. Figure 5 offers an example of an IAEA staff member pursuing a career path in the field of NST.

John Kinker

Nuclear Support Systems Coordinator

IAEA
Department of Nuclear Energy

1989	BS in Environmental Engineering **New Mexico Institute of Mining & Technology**	EDUCATION
1990	Project Engineer **Law Environmental Inc**	PRIVATE
1993	Senior Engineering Services Group Leader/Project Manager **Eberline Services**	PRIVATE
2001	Senior Engineer **PrSM Corporation**	PRIVATE
2005	Senior Project Manager/Engineer **Omicron Safety and Risk Technologies**	PRIVATE
2006	Waste Management Information Specialist **IAEA- Nuclear Fuel Cycle/Waste Technology Division**	IAEA
2013	Independent Consultant **Various**	PRIVATE
2014	Nuclear Support Systems Coordinator **IAEA- Department of Nuclear Energy**	IAEA

Figure 7.

Example of an IAEA staff career path

Conclusion

"Assessment is today's means of modifying tomorrow's instruction"

Carol Ann Tomlinson

Assessment, monitoring and evaluation are all crucial for determining whether a strategy for the education sector has been successfully implemented. The relationship between learning and accountability is strengthened and a feedback mechanism works to further improve the delivery of NST topics in light of contemporary teaching and learning trends.

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Jane Gerardo-Abaya, Director of the IAEA Technical Cooperation Division for Asia and the Pacific with Marina Mishar, Section Two Head of the IAEA Technical Cooperation Division for Asia and the Pacific, and Bridget Carter, Associate Project Officer, work with experts to develop the Guidebook Series for Introducing NST in Secondary Education.
(Photo: Nuclear Malaysia).

Guidebook series for introducing
Nuclear Science and Technology
in secondary education

Guidebook 5

Assessment, monitoring and evaluation

January 2023