WORKING DOCUMENT

Guidebook series for introducing
Nuclear Science and Technology
in secondary education

GUIDEBOOK 4

Teaching strategies and learning facilitation tools

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.

Over the years, there has been a shift in the main role of teachers from solely teaching and acting as a content provider to now becoming a facilitator who provides resources, monitors progress and encourages students to problem solve. This guidebook offers examples of teaching strategies, as well as learning and facilitation tools that have been used in the delivery of NST in secondary school education by some MS. It provides a variety of educational resources, some of which may serve as models of methodology for others to adopt or adapt in their own learning environment.

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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List of abbreviations

AELB	Atomic Energy Licensing Board
ANSTO	Australian Nuclear Science and Technology Organization
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
IAEA	International Atomic Energy Agency
INIS	International Nuclear Information System
IoT	Internet of Things
LMS	Learning Management System
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MoE	Ministry of Education
MS	Member State
MOOC	Massive Open Online Course
NST	Nuclear science and technology
NucleAR	Nuclear Augmented Reality
PBL/PrBL	Problem based learning
PHEIC	Public Health Emergency of International Concern
PNRI	Philippine Nuclear Research Institute
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering and Mathematics
TEPCO	Tokyo Electric Power Company

1. Introduction

Defining a good curriculum is one thing but achieving it requires many resources. The most basic elements of curriculum material are the learning resources and tools through which the teacher plans the lesson and teaches it to the student in the class. These tools will be determined by the structure of the curriculum. In addition, a proper classroom environment needs to be conducive enough to stimulate effective learning.

The traditional classroom teaching strategies and methods for supporting student learning, which mainly consists of rote facts and knowledge that students need to memorize, have to change in tandem with lifelong learning. This requires innovative teaching techniques and methods that not only increase students' interest and motivation to pursue NST, but also replaces rote memorization with critical thinking, comprehensive understanding, imaginative learning and the appreciation of subtlety. Additionally, this was of teaching shapes students to perform better in the learning environment as they are empowered to inculcate basic skills, make their own decisions, be respected as individuals and trusted with personal responsibility. These are all good traits that students need to thrive in the future environment.

The importance of curriculum material lies also in its management. Learning and facilitation materials need to be made available and used, but they also need to be maintained. Examples of such materials and tools are textbooks, exercise booklets, case studies, lesson plans, simulations, (virtual) lab experiences, homework assignments, charts and tables available through publications such as brochures, posters, and online resources. This teaching strategies, as well as the learning and facilitation tools, outlined in this guidebook will be very beneficial to the education sector as they contain both sources for students and instructional material for teachers.

Innovative teaching techniques and methods not only increase students' interest and motivation to pursue NST, but also replaces rote memorization with critical thinking, comprehensive understanding, imaginative learning and the appreciation of subtlety.

2. Specific objectives

The prime objective of discussing novel approaches in the use of teaching and learning tools is to introduce interest, learning enthusiasm and an effective grasp of Science, Technology, Engineering and Mathematics (STEM) concepts in students. The use of modern technology, approaches and mechanisms has already been widely discussed in various fields of education.

The objectives of this guidebook are to:

- provide guidance to teachers, policy makers and local experts to establish and/or improve their local teaching approaches to NST
- introduce a set of successfully implemented and verified teaching models/tools to MS
- share information, experiences and feedback among MS
- instill an enthusiastic learning ("WOW" factor) in both teachers and students
- motivate the development of local tools, kits, instruments and methods to deliver NST knowledge
- reduce the burden of conventional teaching and assessment methods.

It is well understood that cooperation between MS, educational institutions, local experts and developmental organizations will be instrumental in achieving these objectives.

3. Different concepts of learning and facilitation

The terminology of teaching and learning has somewhat changed in recent decades, so that the teacher is now seen more as a facilitator in learning. This is because the 21st century skillset, or breadth of skills required for quality student learning, is now understood to encompass a range of competencies, including:

- critical thinking
- problem solving
- creativity
- communication skills
- digital and technological literacy
- global awareness.

The concept of teaching strategies has also undergone a transformation. Previously, teachers used theory-based learning but now the current learning model leans more towards inquiry-based or phenomenon-based learning.

Traditional theory-based learning has long been used in the education system and has its own advantages. Students study a principle or idea on which the practice of an activity is based, and then they apply their knowledge through in-class exercises and laboratory activities. However, the downside is that this way of teaching relies heavily on teachers' knowledge and time to impart learning. Some critics have even called this a 'spoon feeding' type of learning.

In contrast, inquiry-based learning incorporates the active participation of students by involving them in posing questions and bringing real-life experiences to the classroom. The foundation of this method is channeling the thought process of the students through queries and helping them learn "how to think" instead of "what to think".

Phenomena-based learning has also recently gained in popularity. It is a method of understanding a phenomenon, an observable event, using various methods and perspectives. It takes a broad, multi-faceted look at events and occurrences happening in the real world, such as climate change.

Both inquiry-based and phenomenon-based learning are student-centered in that they allow students to ask questions and find the answers for themselves. This makes them proactively involved in their own learning, applying their knowledge to solve problems. As such, these types of learning demonstrate a shift in the role of the teacher towards becoming a facilitator who provides resources, monitors progress and encourages students to problem solve. Table 1 illustrates the differences between these learning concepts.

Table 1.
Differences between theory-based and inquiry and phenomena-based learning

Theory-based learning	Inquiry and phenomena-based learning
Teacher-centered	Learner-centered
Low gained	High gained
Passive	Active
Conventional approach	Multi-disciplinary instructional approach
Lecture/Demonstration	Inquiry-based or based on real phenomena situations
Uses traditional assessment	Uses alternative assessment

As facilitators, teachers are expected to provide an environment conducive to learning and make the processes of teaching and learning exciting. This guidebook seeks to share some of the learning and facilitation tools that can be used in explaining NST in secondary education.

Some NST learning tools have been developed using the Internet of Things (IoT) such as:

- educational kits (online and offline)
- augmented reality
- virtual reality
- mobile applications
- NST-related mobile games.

Using these tools students had more engaging learning experience and gained a better knowledge of their surroundings in a fun yet educational way.

A summary of the existing material and/or tools was compiled, based on the discussion among the winning and finalist teachers of the Secondary NST Education Competition 2021, who attended the meeting on the Development of Model Curriculum for Secondary Level Education. To access in detail some of the NST topics and possible careers in NST, kindly refer the Asian Network for Education in Nuclear Technology (ANENT) website at www.anentweb.org

The foundation of inquiry-based learning is channeling the thought process of the students through queries and helping them learn "how to think" instead of "what to think".

4. Internet of Things (IoT) in education

The COVID-19 infection which became a Public Health Emergency of International Concern (PHEIC) has had a devastating effect on education. Initial waves led to pandemic-induced school shutdowns, with some MS yet to recover. As yet, the old academic normalcy remains out of reach for many students, educators and parents.

The pandemic forced teachers to use alternative teaching methodologies which were initially alien, unfamiliar and daunting. Virtual classes with adjustment-contained subjects, online virtual tours and home assignments have helped several MS overcome many difficulties. As a result, the use of IoT has exploded, not only in the employment sector but also in the education system.

Virtual classes with adjustment-contained subjects, online virtual tours and home assignments have helped several Member States overcome many difficulties.

5. Concrete IoT tools used for NST education

As IoT platforms becomes more widespread and less expensive to adopt, schools, campuses and other institutions are utilizing the potential of this technology in boosting learning and facilitation. Examples based on what some MS have experienced are shared below.

5.1 NST learning and facilitation documents

NST teaching documents can be found as far back in 1968, when IAEA published its earliest Technical Report Series No. 94 on 'Nuclear Science Teaching'. This report stressed on the importance of having a wide variety of background books on radioactivity and its applications made available for students and teachers. Books are still important today.

5.1.1 Indonesia

Nuclear Smartbook for teachers
(supplementary material/book)

A) Purpose and development concept

This book is a supplement that contains technical content and basic NST knowledge. The book was compiled in 2010 as part of a collaboration between BATAN and the Center for Curriculum and Books – Ministry of Education. It aims to enable teachers to understand basic nuclear science and its uses so that they are ready to teach students through extra-curricular, intra-curricular or outreach activities.

B) Overview, design and specifications

Compiled by expert physics, chemistry and biology researchers, this book explores the relationship between nuclear science and the three sciences listed above for students to learn at school. Curriculum researchers were involved in determining the boundaries of the material following the applicable curriculum learning indicators. This supplement contains ten chapters:

- two (2) chapters on basic radiation knowledge
- five (5) chapters on nuclear and radiation applications
- three (3) chapters on radiation protection and radioactive waste.

The book can download via the link in the reference.

C) Standard use

This book was created and distributed free to teachers at the senior secondary school level when they participated in training programs both offline and online.

D) Points to be noted

This book is written in Indonesian, but it is possible for it to be translated it into English.

E) References and remarks

The book can download via:
https://drive.google.com/file/d/1YdnGeeaX0ZC-D-J5DbIC5FQibHO8YCHd/view?usp=sharing

Figure 1.
Nuclear Smartbook for teachers in Indonesia.

5.1.2 Japan

Teaching and learning textbook “Let’s Start Learning Radiation”

A) Purpose and development concept

The Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan published supplemental teaching and learning material on radiation for secondary school students and teachers in Japanese in October 2011, after the disaster at the Fukushima Daiichi Nuclear Power Plant. This teaching and learning material is designed to give a clear explanation of radiation and covers various topics for school education.

B) Overview, design and specifications

Two textbooks for primary students and secondary students, and two educational guidebooks for teachers for primary and secondary schools were produced. Each book consists of 20–30 pages. The teachers’ guidebooks include the content of student’s book, with more detailed information to aid explanation to students, as well as points for learning and teaching.

C) Standard use

MEXT distributed the printed textbooks to all students in Japan. Every teacher can freely use the textbook in their class based on his/her education plan.

D) Points to be noted

The radiation textbooks published by MEXT are required to be scientifically accurate in terms of content as well as offering a balanced perspective that does not fluctuate with personal values. MEXT formed an editorial committee consisting of eight (8) radiation experts — five (5) university professors nominated by MEXT and three (3) experts nominated by radiation-related societies — and five (5) schoolteachers from two (2) primary schools and three (3) secondary schools. The books were reviewed and published with the support of three radiation-related societies and one national research institute (National Institute of Radiological Sciences).

E) References and remarks

This textbook can be accessed via:
https://jopss.jaea.go.jp/search/servlet/search?5047806&language=1

The original textbooks were published by MEXT, Japan, and were translated into English by Japan Atomic Energy Agency (JAEA). The newest textbooks are the 3rd edition, which is only available in Japanese:
https://www.mext.go.jp/a_menu/shotou/housyasen/1410005_00001.htm

5.2 Website and online resources

5.2.1 Australia

Elementals

Australian Nuclear Science and Technology Organization (ANSTO)

A) Purpose and development concept

Elementals is a fun educational app for learning the Periodic Table. Teachers and students find this app useful both in supporting science education in the classroom and for students learning and memorizing their own time.

B) Overview, design and specifications

This game can be downloaded to be played on either iPhones or Android phones or by using an internet browser. There are five different games based on the Periodic Table and chemical compound formulae. The participant may be able to answer multiple choice questions directly through previous knowledge or through educated guesses. Player scores are provided at the end of the game. Only English versions are presently available.

C) Standard use

This app can be used by secondary school students for independent study or by teachers in a classroom setting with a large touchscreen and some student volunteers to enter answers on behalf of the class.

D) Points to be noted

Students learn about element names, element symbols, atomic numbers and element groups (alkali metals, halogens, etc).

E) References and remarks

The app, which is copyright of ANSTO 2013, can be download from
www.ansto.gov.au/education/resources/apps
or played directly on a browser:
https://archive.ansto.gov.au/elementals/menu.html

Halflife Hero

Australian Nuclear Science and Technology Organization (ANSTO)

A) Purpose and development concept

Halflife Hero is a fun educational app that teaches how nuclear medicines and industrial isotopes are created, as well as their benefits to society.

B) Overview, design and specifications

Participants take on a role as the director of a nuclear research reactor, using a simplified version of ANSTO's OPAL reactor. The goal is to supply as much nuclear medicine and industrial isotopes as possible to hospitals and industries around the world. These isotopes are Iodine-131, Molybdenum-99, Lutetium-177, Cobalt-60, Iridium-192 and Silicon-31.

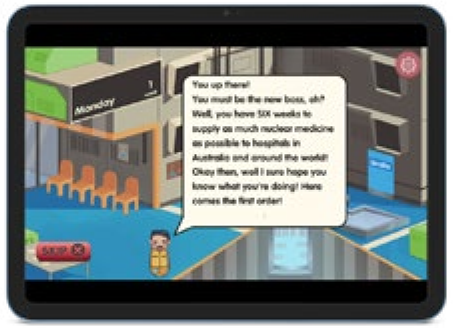
Participants take orders from customers, and then drop the correct precursor element into the reactor to be irradiated. Once the isotopes are created, participants must process and deliver the product before too much of it decays. At the end of each week, the customers give feedback on what their nuclear medicine or industrial isotope was used for.

C) Standard use

Halflife Hero is a self-directed game that easily can engage school-aged students for 30 minutes.

D) References and remarks

Halflife Hero was produced for ANSTO by 2and2. This app can either be used online via http://archive.ansto.gov.au/static/halflifehero/ or downloaded for iOS.



ANSTO YouTube channel

Australian Nuclear Science and Technology Organization (ANSTO)

A) Purpose and development concept

This YouTube channel is a library of short videos showcasing nuclear science research, expertise and infrastructure at ANSTO. It is used by departments across ANSTO for various communication, education and marketing purposes.

B) Overview, design and specifications

Most videos are short summaries (less than five (5) minutes) of specific concepts, research projects or news stories, although some are a longer format and may include recordings of events or presentations.

C) Standard use

There is no standard use, but some use cases include:

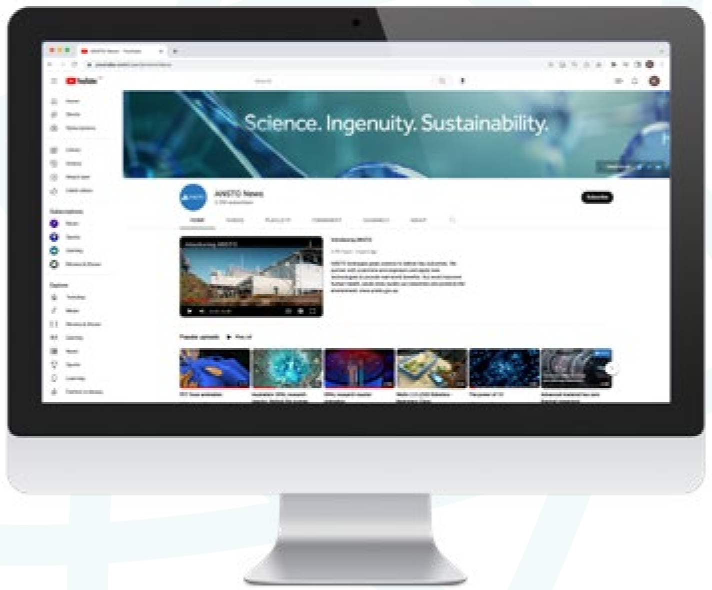
- The OPAL research reactor animation www.youtube.com/watch?v=GooWJywwfgo&t=87s is commonly used by ANSTO Education Officers to demonstrate the functions of the OPAL reactor during site tours. These videos are often used with the sound off so staff can provide their own voice over as appropriate for the audience.
- The PET scan animation www.youtube.com/watch?v=oySvkmezdo0&t=5s is used by many secondary students during independent research for school assignments when they need to understand how nuclear medicines are used for disease diagnosis.
- The "Power of 10" animation www.youtube.com/watch?v=yvpPHoHh420 is used by ANSTO Education Officers during online learning sessions with secondary school students to illustrate the scale of atoms relative to other objects.
- Videos such as "Day in the Life of Australian Nuclear Medicine" and "Day in the Life of a Radioactive Waste Worker" are used by the ANSTO communications team on social media to educate the general public about the benefits of nuclear medicine and the responsibilities that come with it.
- Small sections of the "Mud wasp building nest helps to date Aboriginal Rock Art" video www.youtube.com/watch?v=ZstN2zU_Ctc are used regularly in online learning sessions with secondary school students to demonstrate how these wasps build their nests on cave walls in the Kimberley Region of Northern Australia. Fossilized nests from mud wasps are analyzed by ANSTO using carbon-dating and are used to estimate the age of Aboriginal rock art paintings.

D) Points to be noted

YouTube is a good repository system for these videos, storing videos from ten (10) years ago and older, although the user needs an internet connection in order to show them. These videos can easily be embedded in PowerPoint Presentations.

E) References and remarks

The YouTube channel website is available at www.youtube.com/c/ANSTOVideosChannel/featured This YouTube channel is operated by ANSTO (www.ansto.gov.au).



5.2.2 Indonesia

NucleAR

(Nuclear Augmented Reality)

A) Purpose and development concept

NucleAR is a digital platform designed to visualize and educate people on how nuclear technology works. Four topics have been developed in this application, namely: how NPP works, food irradiation, malignant/cancer treatment, and DNA mutation. This app was created so that nuclear and radiation can be studied using pleasing visuals by various levels of school students, especially those looking for nuclear technology.

B) Overview, design and specifications

The app can work on smartphones/gadgets with the Android platform. After the app is installed and opened, users need to point the gadget's camera at the image associated with the desired object (QR code implanted). Visual 3D appears on the surface of the image and can only be seen through the gadget used for scanning. The NucleAR app is not available on the Google Play Store but can be downloaded via a secure apk file (link in reference).

C) Standard use

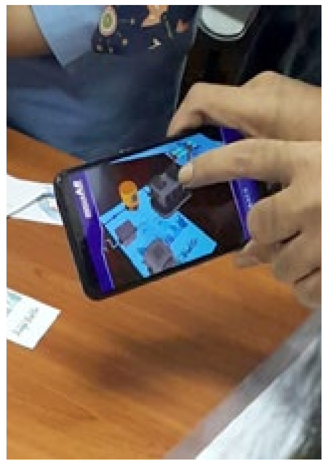
The app is free and can be used by anyone with an Android platform. The app only provides a visual form without explanation, so educators need to understand how radiation works in order to provide understanding for students.

D) Points to be noted

It is important to know that this app is a visual aid. Users or students need to already know how nuclear technology and radiation in these objects work to understand the symbols, shapes, and movements that NucleAR visualizes. If the user does not understand radiation, an educator or teacher is required.

E) References and remarks

The NucleAR app can be viewed via:
https://drive.google.com/drive/folders/1ON1HC2qZBwgMZDQCOn63rPLjl-bsTXQh?usp=sharing
The folder has four (4) objects (QR code implanted) and 1 apk file to install.



Developing a virtual nuclear facility visit

A) Purpose and development concept

A visit to a nuclear facility is one of the attractions of NST education for school students and teachers. The experience of visiting a facility will open the eyes of the younger generation and show them that nuclear technology is safe when managed by the right hands. During the initial wave of the pandemic, physical visits to nuclear facilities in Indonesia were not available. This virtual visit involves a hybrid concept, using recordings and virtual reality while also interacting directly.

B) Overview, design and specifications

The virtual visit is 2.5 hours long and consists of two (2) main parts: recorded materials and interactive sessions.

i) Recorded materials

In this section, the visit organizer (nuclear agency) prepares recorded materials in the form of video explanations. Video explanations of the four objects most liked by school students (from data based on evaluations of physical visits over the last few years) include recordings of guides/staff explaining the objects as they are visually represented. The four (4) explanation objects are:

1. radiation surrounds us (natural and artificial radiation)
2. radiation protection
3. nuclear technology for mutation breeding
4. nuclear technology for food irradiation.

Organizers can create a virtual reality tour inside a nuclear facility. In this example, the Indonesian nuclear communicator team has created a virtual reality tour of the reactor. So that virtual visit participants can feel like they are visiting a reactor the teacher can make virtual reality creations simply by using the 360^{o} cameras that record the paths and procedures for visitors.

ii) Interactive sessions

Interactive sessions contain greetings and live questions and answers via video conference or webinar platforms familiar to students. The guide greets the visitors live and the officers answer questions using the pre-recorded material. The live session maintains the concept of interactivity, and allows virtual visitors feel a connection to the nuclear facilities.

C) Standard use

In preparing a virtual facility tour, it is necessary to pay attention to the safety and security requirements of nuclear facilities and to comply with public information regulations. The organizers need to coordinate with the related nuclear security parties.

D) Points to be noted

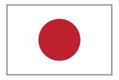
In creating virtual visits the following things are important:

- If the nuclear agency creates the virtual visit, attention needs to be paid to the material's suitability in terms of the visitor demographic. Multiple objects can be prepared to be assigned to different groups if required.
- If the educator created the virtual visit, strong collaboration and communication with the nuclear agency are essential, including selecting a secure object and an agreed visit schedule so that both parties can continue to be involved.

E) References and remarks

The example of the virtual visit can be viewed at:
https://drive.google.com/file/d/1nLuLrorwT3bxWhJmwCq2FL1EPkRRsq2o/view?usp=sharing
or by contacting Mr Adipurwa Muslich from BRIN (National Research and Innovation Agency of Indonesia (adip004@brin.go.id))

5.2.3 Japan



Graphical flip-charts of nuclear and energy-related topics

A) Purpose and development concept

More than 200 graphical flip-charts can be downloaded for education on nuclear and energy-related topics. Simple, colorful and informative PDFs and JPGs have been prepared.

B) Overview, design and specifications

The graphical flip-charts have been categorized into ten (10) chapters:

- World Energy Situation and Japanese Energy Situation
- global environmental problems
- new energy
- current status of nuclear power plants
- safety of nuclear power generation
- radiation
- nuclear fuel cycle
- radioactive waste
- others
- nuclear power plant accidents caused by the Tohoku-Pacific Ocean Earthquake.

Each chapter consists of about ten (10) PDFs and JPGs for use in PPT lectures. They are available in both Japanese and English versions.

C) Standard use

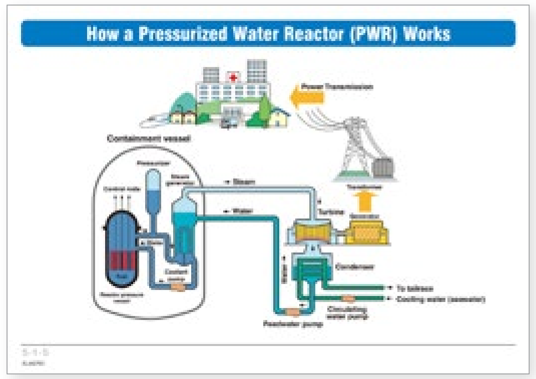
Educators can use all content free of charge to design and prepare their lectures.

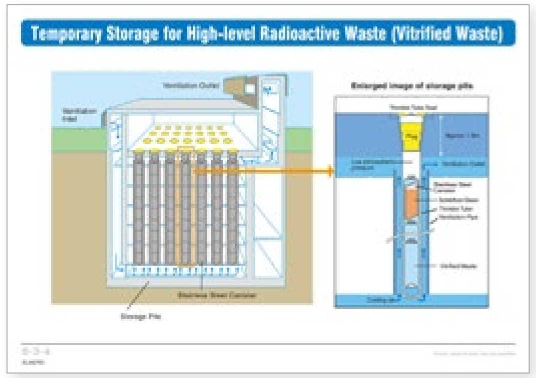
D) Points to be noted

Graphs, illustrations and text may be used for personal, educational, public relations and media purposes, provided that the source is clearly stated and that no alterations are made that would damage the image of the original work. Those seeking to use the material for commercial or for-profit purposes, need to send an email to info*jaero.or.jp, * → @ and ask for permission.

E) References and remarks

The flip-charts can be accessed via
www.ene100.jp/map_title_en
The website is operated by Japan Atomic Energy Relations Organization.
https://www.jaero.or.jp/index_en.html





Information platform "RADI" supporting radiation education for teachers

A) Purpose and development concept

- To support teachers and to provide relevant information, especially for teachers who have little NST expertise and are anxious about conducting radiation lessons.
- To provide logistical support to resolve the social effects of the Fukushima Daiichi NPP accident (for example, anxiety about radiation, harmful rumors, etc.).
- To motivate teachers by organizing contests and other activities.
- To develop a kids' page where elementary, junior high and high school students can study independently

B) Overview, design and specifications

The main content includes:

- examples of teaching practice
- syllabus examples
- experiment examples
- video materials
- photographic materials
- handouts
- infographic materials
- gaming simulation tools
- contest information relating to radiation teaching materials
- contest information for radiation teaching case studies
- columns by experts
- applications form for lending educational tools and delivery of classes
- kids' page, etc.

C) Standard use

Teachers (primary and secondary) use this website when designing and preparing radiation lessons. Anyone can access this website to view a wide range of radiation education content. Registering as a member enables further free support, such as newsletters, lending and delivery of lessons.

D) Points to be noted

A Radiation Education Promotion Committee consisting of five members (former head of national textbook planning in the Ministry of Education, chairman of the National Research Association for Secondary School Science Education, expert on radiation use, expert on radiation effects on the human body and expert on radiation protection) discuss the management policy of the website and review the content to ensure its scientific accuracy and stability.

E) References and remarks

Most of content is in Japanese although some representative videos and handouts are also available in English:

- Japanese page: www.radi-edu.jp
- English page: www.radi-edu.jp/en

RADI is operated by Japan Science Foundation/ Science Museum (www2.jsf.or.jp).

Booklet to provide basic information regarding the health effects of radiation

A) Purpose and development concept

Seven years have passed since the accident at Tokyo Electric Power Company (TEPCO)'s Fukushima Daiichi Nuclear Power Station. The national government seeks ensure that residents who have returned home can rebuild their lives smoothly without worry about their health due to the radioactive materials released by the accident. Based on the Policy Package on Radiation Risk Communication for Achieving Residents' Return (2014), the national government has endeavored to disseminate correct and easy-to-understand information and has strengthened risk communication among a small number of people.

The Radiation Health Management Division, Environmental Health Department, Minister's Secretariat, Ministry of the Environment has collected and compiled some basic knowledge on radiation, making use of the scientific expertise and initiatives of relevant ministries and agencies concerning the health effects of radiation. Since 2012 the Division has prepared and maintained a booklet to provide basic information, working together with the National Institute of Radiological Sciences and the National Institute for Quantum and Radiological Science and Technology.

B) Overview, design and specifications

A number of lecture PDF documents and explanations are available free of charge to help explain various keywords related to radiation.

C) Standard use

This booklet has been utilized in training sessions targeting people engaging in health and medical care, welfare and education, with the aim of fostering personnel who can respond to residents' worries and concerns about their health in Fukushima and neighboring prefectures.

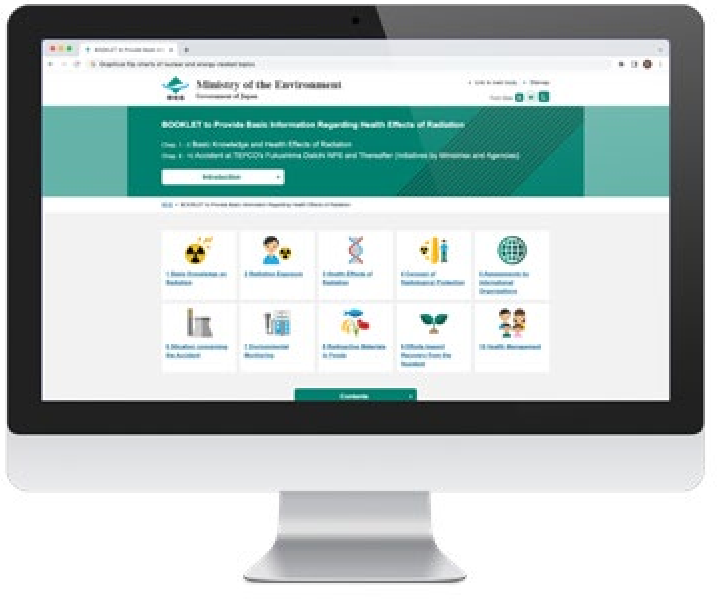
D) Points to be noted

Any person who uses this booklet should indicate the data source as follows:

Source: BOOKLET to Provide Basic Information Regarding the Health Effects of Radiation. Copyright for figures and tables, etc. from sources other than the Ministry of the Environment belong to the relevant sources. Please use data by clearly indicating the sources. See "Copyright/Link" (www.env.go.jp/en/utility/copyright.html) for details.

E) References and remarks

This information can be sourced via the Radiation Health Management Division, Environmental Health Department, Minister's Secretariat, Ministry of the Environment, Government of Japan:
www.env.go.jp/en/chemi/rhm/basic-info/



Educational materials on nuclear emergency preparedness "What to do in such a case?"

A) Purpose and development concept

To deepen understanding of nuclear disaster prevention, educational materials on nuclear disaster prevention have been prepared, including content that simulates preparation and actions.

B) Overview, design and specifications

The materials include a booklet and web-based simulations that enable users to confirm how they should act to protect themselves from radioactive materials in the event of an accident at a nuclear power plant. The video introduces the basics of radiation and its effects on the human body. (Japanese version only as of 1 October 2022. English contents will be opened soon.)

C) Standard use

Educators may use all content free of charge for classroom lessons and preparation.

D) Points to be noted

Figures and tables in publications and other materials may be used for personal use, as well as for educational, public relations and news reporting purposes. The source must be clearly indicated and the content not altered in any way that would damage the image of the original work. For commercial or for-profit use, permission must be obtained via e-mail (info*jaero.or.jp, * → @).

E) References and remarks

The material can be accessed at:
www.ene100.jp/bousai/sp/
This website is operated by the Japan Atomic Energy Relations Foundation
www.jaero.or.jp/

5.3 Classroom simple kits

5.3.1 Indonesia

Simple cloud chamber for background/natural radiation

A) Purpose and development concept

The Cloud Chamber Experiment was introduced by the IAEA and Japanese teams to demonstrate the "WOW" factor within NST. However, in Indonesia, safe radiation sources are difficult for teachers or schools to access and use, so they must borrow from a nuclear agency. So that teachers and schools can bring this "WOW" factor to school independently, a team of Indonesian nuclear communicators have developed the Simple Cloud Chamber using background radiation as a source to observe particle traces. This simple experiment also uses materials and tools from around the school.

B) Overview, design and specifications

An explanation of the basic theory of the cloud chamber, the tools and materials needed, how to assemble it, and tips for conducting observations are attached to the reference.

C) Standard use

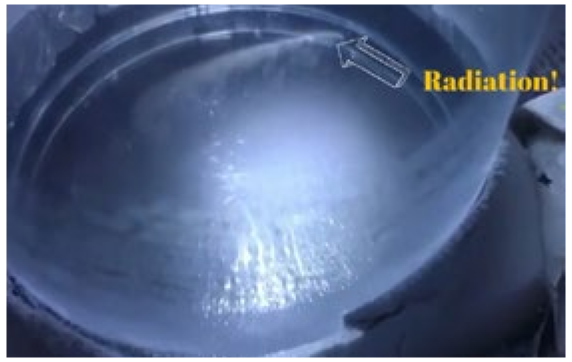
This experiment can give students an overview of the ionization phenomenon and the interaction traces of radiation sources by type. Assembly takes 20-40 minutes while leaving the chamber cold for at least 10 minutes is recommended for successful observations.

D) Points to be noted

- Teachers must systematically prepare the materials for the cloud chambers and dry ice before the experiment.
- Students need to be given an extra warning about cold burns and lack of acidity caused by dry ice.
- It looks even better if the evaporated ethanol is sealed so that it does not leave the container and the lid is fogged and electrostatically charged.
- The time it takes to cool the cloud chamber, and the thickness of the supersaturated layer depends on the size of the container. Differences in the type and amount of radiation can be observed.

E) References and remarks

The technical guide for the Simple Cloud Chamber can be accessed via: https://drive.google.com/file/d/1Ylod40rsylfaQfC-E1_MbKNvhJLO5EfA/view?usp=sharing. A tutorial for the Simple Cloud Chamber can be accessed via: https://drive.google.com/file/d/1hgj4VJYFwuGORdlio2j-tqSKuwSd4aMs/view?usp=sharing



5.3.2 Japan

Graphical flip-charts of nuclear and energy-related topics

A) Purpose and development concept

- To make students feel the "WOW" factor by seeing radiation tracks in their class.
- For students to enjoy assembling a cloud chamber by themselves, and to see radiation tracks when using it.
- To develop understanding of how the natural materials surrounding us emit radiation anytime.
- To learn how the Nobel Prize relates to NST through the story of the cloud chamber's history.

B) Overview, design and specifications

- Container (petri dish, Pyrex, etc.), ethanol, wrapping film, dry ice, sponge tape, black paper, etc.; a radiation source of Petri dish (small) size
- Radioactive ores (e.g., monazite), thorium-containing gas mantles, pencil balloons (electrostatic), granite, dust samplers, uranium glass, thorium-tungsten (welding rods), Crookes tubes, etc.

C) Standard use

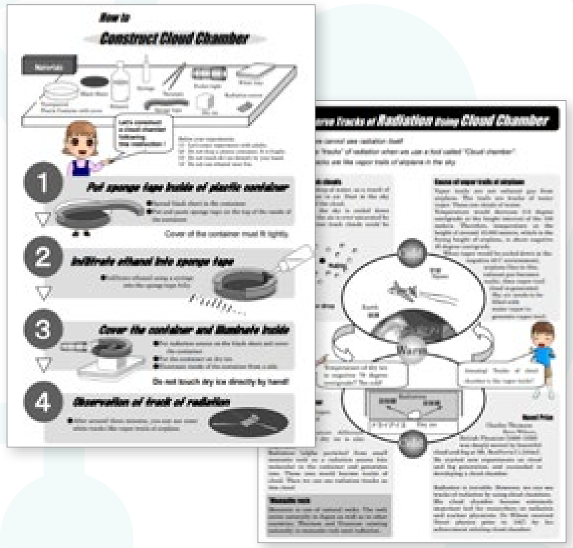
This is an experimental lesson lasting 20–60 minutes that combines the work of assembling a cloud chamber and the observation of radiation tracks. Occasionally, teachers may use instructional videos (www.radi-edu.jp/en/material/) instead of actual laboratory work to give students a taste of the experimental atmosphere. Various radiation tracks can be observed, including alpha and beta radiation, muons and Compton scattering by using this simple tool.

D) Points to be noted

- Teachers need to systematically prepare the materials for the cloud chambers and dry ice before the experiment.
- Students need to be given an extra warning about cold burns and the lack of acidity caused by dry ice.
- It looks even better if the evaporated ethanol is sealed so that it does not leave the container, and the lid is fogged and electrostatically charged.
- The time it takes to cool the cloud chamber and the thickness of the supersaturated layer depend on the size of the container. There are differences in the type and amount of radiation that can be observed.

E) References and remarks

The material is presented in RADI via: www.radi-edu.jp/en/material/
The information platform supporting radiation education for teachers is operated by Japan Science Foundation/Science Museum www2.jsf.or.jp/



GM tube for classroom assembly practice

A) Purpose and development concept

A GM counter is a simple radiation detector which helps in developing understanding of radiation properties such as half-life, penetration power and the inverse square law. Experiments on shielding and the inverse square law can also show students how the radiological protection concept of "as low as reasonably achievable" (ALARA) can be achieved through shielding and distance from source. A handmade air GM counter for radiation education in secondary schools helps students to understand the structure of the GM tube and allows them to experiment with half-lives, as the composition of the gas in the GM tube can be changed at will. This device has the capability to illustrate radiation counts qualitatively through sound and quantitatively through counting. It can be an effective tool at various levels of education: exploiting the sense of hearing at the primary level and counting aspects at the secondary level.

B) Overview, design and specifications

- A 0.3 mm-thick cathode made of 300 kΩ black drawing paper encased in a 55 mm long clear case cylinder of diameter 50 mm with a removable cover that serves as the end window.
- Anode made of stainless steel (SUS) wire of diameter 0.23 mm, folded and twisted.
- Air as active gas with 10–30% butane (or alcohol) as quench gas.
- Optimal operating voltage of 5000–5500 V, customized for the tube with a plug-in safety feature for connecting to the GM tube.

C) Standard use

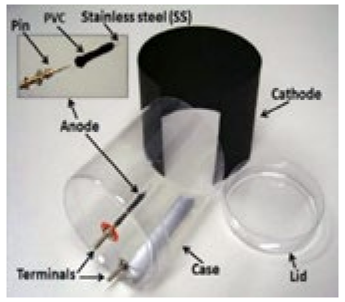
This is an experimental class lasting about 30–60 minutes combines the work of assembling a GM tube with doing experiments on inverse square law, shielding effect and radioactive decay.

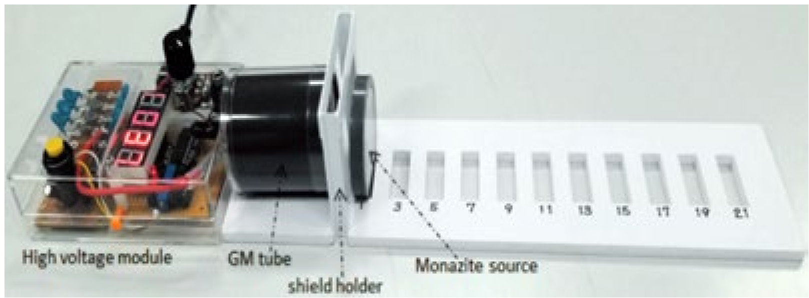
D) Points to be noted

- Thoron gas from a lantern mantle is often used for the practical observation of radioactive alpha decay. Detecting mostly beta particles in the distance experiments and low energy gamma rays in the shielding experiments are also unique.
- GM detects all alpha, beta and gamma (low energy) rays, so particular care must be taken in the choice of shielding materials.
- While handmade GM tubes can be made at an overwhelmingly low cost when compared to commercial GM tubes, the high-voltage power supply unit requires about ten (10) times higher-voltage.

E) References and remarks

The material can be accessed via https://academic.oup.com/rpd/article/184/3-4/535/5480487 and https://www.jstage.jst.go.jp/article/jhps/54/4/54_206/_pdf/-char/ja
The tool was developed by Japan Science Foundation/ Science Museum (www2.jsf.or.jp/), supported by the University of Tokyo.





Radiation card game "RadLab"

A) Purpose and development concept

This is a card game for two (2) participants in which players have to think about the compatibility between a character based on the motif of radiation = "Rad" and a shielding object (shielding object) that prevents radiation = "Block". What does each player have? Should they play a card or draw a card? Sharp tactics and speedy development are hot! While having fun, players can learn about the basic knowledge they need to know now: the relationship between types of radiation and shielding.

B) Overview, design and specifications

Designed for two (2) players six (6) years and up. Game time —15 minutes. There are 70 cards in total, consisting of 28 for attacking, 28 for defending and 14 others.

C) Standard use

The players attack and defend each other repeatedly, with the winner being the player with the most "Syballs", which is a model of cells, left to defend against attacks.

D) Points to be noted

The most important feature of this card game is that even children with no pre-requisite scientific knowledge can enjoy learning the basics of radiation:

The typical types of radiation

- their relationship to shielding
- radiation weighting factors.

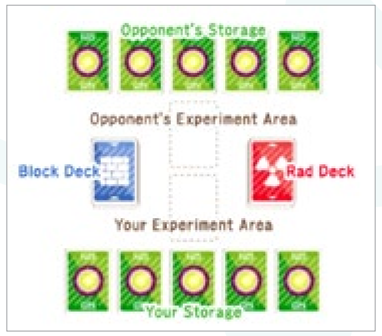
The simplicity of the rules is what makes this game so engaging for children. The appeal is that this game can be picked up immediately either at home or at school.

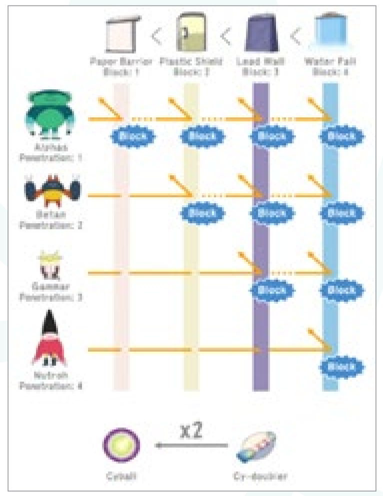
E) References and remarks

This card game can be viewed via: https://www.dropbox.com/s/zr5zse6xosfavyu/0_RLmanual_eng.pdf?dl=0

https://www.dropbox.com/s/s7kn9lwovr8lksx/RadLabplaysheet.pdf?dl=0, and https://www.tansanfabrik.com/post/141193268776/radlab.

The tool was developed by Dr UNO's Radiation Laboratory, supervised by Dr Yuichi Tsunoyama, Kyoto University.





5.4 Advanced tools and infrastructures

5.4.1 Japan

Peltier cooling cloud chamber with wide window

A) Purpose and development concept

- To make students feel the "WOW" factor by seeing radiation tracks in their class.
- To understand that natural materials surrounding us emit radiation anytime.
- To learn how the Nobel Prize is relates to NST through the story of the cloud chamber's history.

The tool does not need dry ice for the experiment to work in class. A development goal for the Peltier cooling cloud chamber was to realize a wide window for observation.

B) Overview, design and specifications

- Cooling method: Peltier element cooling
- Observation surface: circular (diameter 75 mm)
- Illumination: 12 high brightness white LEDs
- Size: about W220×D170×H220 mm
- Body weight: about 2kg
- Supply voltage: AC100–120V or AC200–240V
- Power consumption: about 70W, using liquid: Ethanol
- Radiation source: 220Rn supply mantle and ceramic monazite ball

C) Standard use

This is a 10–15-minute experimental lesson that seeks to observe radiation tracks. The tracks will start to appear in about three (3) minutes after turning on the power. Five (5) to six (6) students can observe simultaneously. Occasionally, teachers may use instructional videos (www.radi-edu.jp/en/material/) instead of actual laboratory work to give students a taste of the experimental atmosphere.

D) Points to be noted

Learning about the cooling mechanism by using Peltier devices also leads to a deeper understanding of science and technology. This device is an example within the Science, Technology, Engineering, Arts and Mathematics (STEAM) educational framework.

E) References and remarks

The material can be accessed via https://kiribako-rado.co.jp/e-goods/, and https://academic.oup.com/rpd/article/184/3-4/539/5480505. The tool was developed by RADO LTD, supported by STIF (NPO Science and Technology Information Forum (https://npostif.org/) and The University of Tokyo.

KIND series
(portable environmental gamma dosimeter)

A) Purpose and development concept

To make students understand the existence and variation of environmental radiation and feel the "WOW" factor in monitoring radiation. The combination of source and shielding allows attenuation and shielding experiments to be carried out and the three principles of reducing external exposure to radiation to be studied. The calibration kit provided allows for simplified calibration.

B) Overview, design and specifications

<KIND-pro>

- CsI (TI) scintillator size (mm): 12 x 12 x 5,
- Sensitivity: over 1,000 CPM/uSv/h
- Measuring time interval 10/30/60 sec, moving average: 60 sec (10 sec update)
- Weight (g): 100, Size (mm): 95 x 60 x 17

<KIND-mini>

- Plastic scintillator size (mm): 12 x 12 x 5
- Sensitivity: over 300 CPM/uSv/h
- Measuring time interval 10/30/60 sec, moving average: 60 sec (10 sec update),
- Weight (g): 100, Size (mm): 95 x 60 x 17

C) Standard use

After the presence and distribution of radiation in the natural environment has been explained to the class, students can use this instrument to measure the radiation around them. The students can then be given the opportunity to measure the surface doses of different materials, to recognize the diversity of radiation fields in different objects and places, and to investigate the causes. Twenty (20) minutes to one hour of practical work is suitable for this.

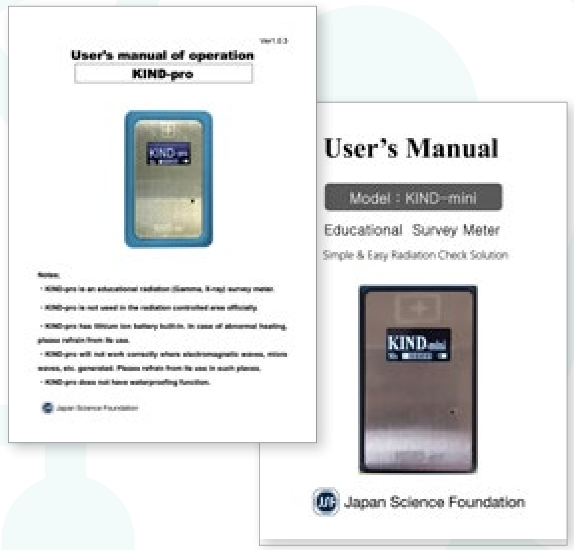
D) Points to be noted

The KIND series are designed to be small and lightweight so that even young children can easily measure environmental radiation dose rates by simply pressing a switch on the front panel. KIND-pro has high sensitivity and is designed for deployment in information and communication technology (ITC) education, allowing measurement data to be recorded internally and output to a PC or other device. The KIND-mini is less sensitive to gamma rays, but more sensitive to X-rays, making it useful for detecting X-rays emitted from Crookes tubes.

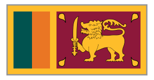
E) References and remarks

The material can be accessed via www2.jsf.or.jp/en/pdf/KIND_pro_manual.pdf, and www2.jsf.or.jp/en/pdf/KIND_mini_manual.pdf

The tool was developed by Japan Science Foundation/Science Museum (www2.jsf.or.jp/), supported by the University of Tokyo and others.



5.4.2 Sri Lanka



Radiation counting system — “RADI-Count”

A) Purpose and development concept

A multipurpose demonstration and experiment tool kit for introducing NST to secondary-level students.

B) Overview, design and specifications

The counter features a GM detector (alpha, beta and gamma sensitive), a control unit with variable high-voltage and sampling time, a complete shielding kit, safe-to-use radioactive samples (natural sand) and other accessories. The counter operates in two modes: counts mode and count-rate mode. Raw data collected from the instrument can be used for statistical experiments and calculations. A newer version is also assisted by a computer interface (optional) for data representation and control. The detachable detector assembly significantly improves the versatility of the device.

C) Standard use

The kit can be used for multiple experiments and demonstrations as follows:

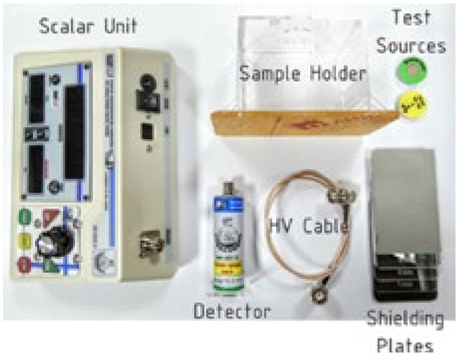
Demonstrations	Experiments
Basic level: • Existence of radiation in our environment • Operation of radiation-based gauge system	***Basic level:*** • Radiation detection and counting
Secondary level: • Randomness of radiation emission • Effect of shielding and source-detector distance	***Secondary level:*** • Principles of radiation protection • Basic characteristics (penetration) of alpha, beta and gamma radiation
Senior high-school level: • Counting statistics • Half-value thickness • Dead-time calculation • Detector efficiency and performance tests • GM detector characteristic curve	

D) Points to be noted

The kit is designed to be an economical, user-friendly and versatile tool, that can cater to various education levels. It can be used effectively in presenting the concepts of basic radiation in a standard scientific manner.

E) References and remarks

Please refer to Reference section at the end of this guidebook.



A portable radiation detector — “RADI-Rate”

A) Purpose and development concept

An easily operable, portable radiation detector that can measure the background radiation level. Suitable for introducing radiation- related concepts to entry-level students.

B) Overview, design and specifications

The simple survey meter features a Geiger detector and digital display as well as three buttons (to reset sampling time, to enable sound and off/on button). It is operated with a market-available battery. Data display is in counts-per-second (cps). A self-diagnostic system is included to notify any instrument faults to the user. Developed to be economical and portable, the device also has a version with an external detector attachment that can be used in several other radiation-related school experiments (principles of radiation protection, alpha, beta sensitivity).

C) Standard use

RADI-Rate is a radiation ratemeter with gamma sensitivity. It can be used in either classroom or field activities/demonstrations to measure radiation levels.

D) Points to be noted

The detector is a small, handheld instrument, that can be used in education demonstrations for radiation education. Designed with minimum maintenance requirements and sold as a non-profit product.

E) References and remarks

The survey meter was developed by the Nuclear Instrumentation Laboratory, Radiation Protection & Technical Services Division, Sri Lanka Atomic Energy Board, Orugodawatta, Wellampitiya, Colombo 10600, Sri Lanka (nirodha@aeb.gov.lk, +94 11 253 3427/8).

A DIY radiation detector "TOKY"

A) Purpose and development concept

A self-assembly (do-it-yourself/DIY) simple radiation counter for secondary level students with DIY/ electronic enthusiasm. The purpose of the kit is to introduce radiation science into hobbies and motivate the "WOW" factor. It also aims to provide motivation to teachers in introducing hobby kits into the classroom.

B) Overview, design and specifications

The extremely inexpensive, simple counter features a small Geiger detector and display. The kit is available as a self-assembly kit for students with very basic electronic knowledge. The kit consists of a circuit board, GM detector, necessary electronic components and assembly guide. A new version with Silicon detectors is also under development. TOKY is designed for secondary level students/hobbyists who share an interest in electronics.

C) Standard use

TOKY is a simple counter. It counts the number of radiation pulses detected by the minute Geiger detector. It also has a pulse output so a student can connect it with an external computing system (Arduino, PIC, Raspberry Pi etc.) to extend the use of the kit.

D) Points to be noted

The kit is designed to be an economical, easy-to-assemble device with extension flexibility. It is suitable to be used as a co-curricular/extra-curricular activity for secondary-level teachers and students.

E) References and remarks

The kit was developed by the Nuclear Instrumentation Laboratory, Radiation Protection & Technical Services Division, Sri Lanka Atomic Energy Board, Orugodawatta, Wellampitiya, Colombo 10600, Sri Lanka, (nirodha@aeb.gov.lk, +94 11 253 3427/8).

5.5 Online learning resources

A variety of online learning resources have been made available to help ensure continuity in educational activities. This can support learning and facilitation at various level. Some of the online resources includes:

Learning Management System (LMS)

Learning Management System (LMS) is a set of principles or procedures that has elements or components that are organized for a common purpose, or according to which something is done. It can be done manually, but with current IoT, there are various software that can provide same services in shorter time. Therefore, all the curriculum, co-curriculum, outreach activities, can be managed well using a learning management system that helps organizations such as schools to deliver learning materials to students quickly and efficiently. In other words, using a platform like LMS enables schools to create and manage lessons, courses, quizzes, and other classroom materials. Additionally, it permits teachers to keep track of a student's progress in terms of subject completion, knowledge gaps detection, involvement and engagement level, and time taken to complete the course.

The Philippines Department of Education (DepEd) has prepared an LMS that can be used by the teachers and learners to adopt online classes as a modality by which learning would be delivered (https://lms.deped.gov.ph/). At the same time, other resources can be reviewed through this link

- Deped Youtube Channel www.youtube.com/watch?v=sdIYXUSv1Vk
- Deped Resource Portal
- https://lrmds.deped.gov.ph

Example of other existing LMS platform that can be of used for NST learning and facilitation resources includes; Asian Network for Education in Nuclear Technology (ANENT) and Australia's Nuclear Science and Technology Organisation, (ANSTO). ANENT is a regional partnership supported by the IAEA for cooperation in capacity building, human resource development and knowledge management in nuclear science and technology, while ANSTO is as national nuclear research and development organisation and is the centre of Australian nuclear expertise.

Social Media: Facebook Page, Instagram, Twitter

Facebook, Instagram, Twitter and TikTok are examples of free social media platforms for online news and social networking. The main difference between Instagram and Facebook is that Instagram allows posting photos and short videos, whereas Facebook allows sharing various types of media, including photos, short and long videos, articles, website links, and quizzes. Twitter not only broadcast short posts known as tweets that can be in the form text, videos, photos, or links, but also has a microblogging service, a combination of blogging and instant messaging as part of its communication system. Meanwhile, TikTok is a video sharing app that has wide selection of sounds and song snippets, along with the option to add special effects and filters as well as the reactions feature which allows users to record their reactions. These are used in conducting threaded discussion where an online posting on a specific topic and students are asked to post their answer on the discussion forum. Students can read the messages and respond to them. This group of messages with the initial message and responses is called a 'thread'.

Quipper

This is an education technology company that provides an online LMS on e-Learning, coaching, tutoring, and assessment services for K-12 or secondary school education in Japan, Indonesia, the Philippines, and Mexico. The advantage of using Quipper is that learners and facilitator can continue learning anytime, anywhere through their mobile phones even without an internet connection. It has been studied that Quipper is effective towards students' cognitive outcomes. Further exploration can be done through this link-
https://link.quipper.com/en/login

Padlet

Padlet is, simply put, an online noticeboard. It gives teachers a blank slate to customize their own platforms and add numerous media resources like videos, images, helpful links, a classroom newsletter, fun classroom updates, lesson material, answers to questions, and more. This then facilitate students to use it as a reference for a lesson topic or look back at daily lessons, keep up to date with school events, or access it as a class document hub. It is a one-stop sharing platform between students and teachers, offering cooperative creation, high levels of security and privacy, and plenty of sharing options.

Website

A website is a collection of publicly accessible related material that contains text, images, and may also include video, audio or other media, interlinked Web pages that share a single domain name that is created by an individual or organization. Besides providing information, websites feature functionality that enables users to complete tasks, such as searching the site, submitting an online form, or using interactive design features.

An example is the IAEA website called the Nuclear Science & Technology and International Nuclear Information System (INIS). INIS hosts one of the world's largest collections of published nuclear literature on the peaceful uses of nuclear science and technology with multilingual thesaurus. It covers all areas of IAEA's activities, including nuclear engineering and technology, nuclear safety and radiation protection, safeguards and non-proliferation, applications of nuclear and isotope techniques, nuclear and high energy physics, nuclear and radiation chemistry, nuclear applications in life sciences, legal aspects, and environmental and economic aspects of nuclear and non-nuclear energy sources.

Conclusion

*"Tell me and I forget,
teach me and I may remember,
involve me and I learn."*

Benjamin Franklin

Effective learning and facilitation are more than just the successful transference of knowledge, skill or application around a particular topic. By encouraging full participation and cultivating a shared responsibility among students, effective teaching ensures that a surface-level approach is replaced by deeper, student-driven and thorough learning.

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