Curriculum Guidelines for the 12-Year Basic Education

Elementary School, Junior High School, and Upper Secondary School

The Domain of Natural Science

Ministry of Education

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I. Fundamental Beliefs

Science originates from curiosity or needs that humans have toward their surroundings. Humans observe and study a variety of phenomena and variants in nature and apply science in solving problems, adapting to the environment, and improving their lives. While civilization revolutionized, science continued to be developed and gradually became an integral part of our culture. Living in modern society, we are surrounded by innovative technology but troubled by information overflow and ecological issues due to resource exploitation. Thus, our citizens should be equipped with science competencies, which include, understanding the contribution and limitation of science, capabilities to utilize scientific knowledge and methods, combined with a rational attitude and innovative thinking when making judgments and taking actions to deal with science-related issues in their lives. Meanwhile, we must cultivate prospective scientific talents, to lay a robust foundation for human civilization, and for the future development of society and economy.

Science learning should start from motivating students' curiosity toward science and cultivating students' desire for active learning. From there, we should lead students to build their learning upon their prior experiences and further help them to conduct active exploration, experimental operations and multiple learning. In this way, we help students become equipped with the core knowledge of science, as well as the communication abilities for scientific inquiry, practices, and argumentation. Each learning stage should emphasize the meaning and methods of "inquiry and practices." In order to help students comprehend and apply the seven cross-subject concepts of natural sciences (material and energy, structure and function, system and scale, change and stability, interaction, science and daily life, resources and sustainability), we provide a coherent and integrative learning experience focused on a curriculum integrating cross domains/subjects. To reinforce the above objectives, the contents of "Natural science inquiry and practices" courses are added to the senior high schools, which should account for one-third of the Ministry of Education mandated credits in the discipline of natural sciences.

The arrangement of the contents of science learning material must take into consideration the rapid development of scientific knowledge and the inter-connection between science, technology, and other domains/subjects. The organization and selection of course materials must be coherent and integrative. The choice of core concepts should both depend on the characteristics of students in each learning stage, and connect with cross-subject concepts and

socio-scientific issues. Students can then develop their science competency via various approaches, such as inquiry and project-based courses. A citizen with science competencies is an individual who can understand the core concepts of scientific knowledge, who has inquiry skills with a good attitude toward science, and who also has basic understanding of the nature of science.

Therefore, to fit the objective of "taking initiative," students should foster their interests in natural sciences and become active learners while learning natural sciences. While participating in inquiry and practice process, students should actively interact with others and their surroundings, as well as utilize different tools to achieve effective communication, and to meet the goal of "engaging in interaction." For "seeking the common good," students should employ their understanding of the nature of science in order to learn to appreciate the beauty of nature, and to properly utilize natural resources.

II. Curriculum Goals

Based on the aforementioned fundamental rationale, the goals of the natural sciences curriculum for the 12-Year Basic Education are as follows:

1. Encourage students' passion and potential toward scientific inquiry: Facilitate students' curiosity and imagination toward natural sciences, ability to apply rational thinking, and freedom to unleash their potentials.
2. Develop students' science competencies: Furnish students with essential scientific knowledge, abilities of inquiry and practice, and attitude toward science. Using these competencies in the spirit of truth seeking, students can communicate effectively in real-life contexts and participate in the decision-making and problem-solving of social issues, as well as understand and reflect on scientific contents reported by media.
3. Consolidate the foundation of learning science and applying technology: Develop students' positive attitudes toward science and interests in learning science, on top the habit of applying technology to learn and solve problems. This consolidation builds a strong foundation for students to adapt to living in the age of science and technology.
4. Cultivate students' sense of social responsibility and the value system and actions necessary for protecting nature: Assist students to appreciate the beauty of nature, to cherish life, and to deepen their appreciation into a caring and active attitude toward resource preservation.

Students will then be willing to build a rational society and a sustainable environment.

5. Preparation for career development: Enable students to make further efforts to improve their scientific knowledge, whether out of personal interest, in private life or at work. Through this stage of learning, students will be ready to prepare for their next stage of career development.

III. Time Allocation and Subject Combinations

<table>
<tr><td rowspan="3">Educational Stage
Learning Stage
Year
Category</td><td colspan="4">Elementary School</td><td colspan="3">Junior High School</td><td colspan="3">Upper Secondary School</td></tr>
<tr><td colspan="2">2nd Learning stage</td><td colspan="2">3rd Learning stage</td><td colspan="3">4th Learning stage</td><td colspan="3">5th Learning stage</td></tr>
<tr><td>Third</td><td>Fourth</td><td>Fifth</td><td>Sixth</td><td>Seventh</td><td>Eighth</td><td>Ninth</td><td>Tenth</td><td>Eleventh</td><td>Twelfth</td></tr>
<tr><td>Required /Compulsory</td><td colspan="4">3 sessions/ week</td><td colspan="3">3 sessions/ week</td><td colspan="2">12 credits</td><td></td></tr>
<tr><td>Enriched elective subjects/ Advanced</td><td colspan="7"></td><td colspan="3">32 credits</td></tr>
<tr><td>Notes</td><td colspan="10">
1. The natural sciences course at the elementary school stage is structured based on the principle of domain integration, which follows on the Life Curriculum at Stage I. The number of learning sessions for the Natural sciences domain at the second and Stage IIIs is 3 sessions per week.
2. The number of learning sessions for the Natural sciences domain at the junior high schools stage (Grades 7 to 9) is 3 sessions per week. There are 6 semesters during the 3-years. The compilation of textbooks and teaching sessions are distributed in principle as follows: Biology 6/18, Physics and Chemistry 10/18, and Earth Sciences 2/18. Plus there is at least 1 cross-subject unit for each semester, to implement the “Inquiry and Practices” as a cross-subject and theme-based learning content.
3. The MOE-mandated required courses of Natural Sciences in the upper secondary school curriculum include 12 credits, in which, at least a third of the total credits should be the cross-subject and theme-based content-- “Inquiry and Practices”. The courses are planned as follows:

<table>
<tr><th>Domain</th><th>Subject</th><th>Credits</th><th>Remarks</th></tr>
<tr><td rowspan="4">Natural Sciences</td><td>Physics</td><td>2-4</td><td rowspan="4">A third of the MOE-mandated credits must contain cross-subject and theme-based “Inquiry and Practices.”</td></tr>
<tr><td>Chemistry</td><td>2-4</td></tr>
<tr><td>Biology</td><td>2-4</td></tr>
<tr><td>Earth sciences</td><td>2-4</td></tr>
</table>
</td></tr>
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Notes

4. The number of enrichment and expanded elective credits for the upper secondary school curriculum are 32 credits, which include Elective Physics 10 credits, Elective Chemistry 10 credits, Elective Biology 8 credits, and Elective Earth Sciences 4 credits. The courses are planned as follows:

Subject	Course Title	Credits
Elective Physics	Mechanics I	2
	Mechanics II and Thermal Physics	2
	Waves, Sound, and Light	2
	Electromagnetic Phenomena I	2
	Electromagnetic Phenomena II and Quantum Phenomena	2
Elective Chemistry	Matter and Energy	2
	Chemical Structure and Kinetics	2
	Chemical Reaction and Equilibrium I	2
	Chemical Reaction and Equilibrium II	2
	Organic Chemistry and Applications	2
Elective Biology	Cells and Genetics	2
	Origin of Life, and Plant Structure & Function	2
	Structure & Function of Animal	2
	Ecology, Evolution, and Biodiversity	2
Elective Earth sciences	Geology and the Environment	2
	Atmosphere, Ocean and Astronomy	2

IV. Core Competency

The “Curriculum Guidelines of 12-Year Basic Education - General Guidelines” emphasizes the cultivation of “lifelong learners” with a humanistic approach. Divided into three broad dimensions of “autonomous action,” “communication and interaction,” and “social participation,” it serves as a link between educational stages and as the main axis of various domains/subjects. The core competencies in the field of natural sciences stress observation, logical thinking, and reasoning. The students use this as the basis to learn knowledge, and plan and conduct experiments, leading to their problem-solving skills. These competencies are in line with “physical and mental wellness and self-advancement,” “logical thinking and problem solving,” and “planning, execution, innovation, and adaptation” covered in “autonomous action.” The emphasis on using charts and graphs to express, present findings, appropriately using media (internet, books, etc.) and technological information, and appreciating the beauty of science are in line with the “semiotics and expression,”

"information and technology literacy and media literacy," and "artistic appreciation and aesthetic literacy" covered in "communication and interaction." Students will also learn to cooperate with others to study and explore science, then take the initiative to care about environmental public issues, and care for the global environment, which meets the goals of "moral praxis and citizenship", "interpersonal relationships and teamwork", and "multi-cultural and global understanding" covered in "social participation." The core competencies in natural sciences are diverse and unique, and the specific content in the list can be adjusted and integrated with other core competencies during application. The table below illustrated the core competencies in each field of Natural Science.

Core Competency Dimension	**Core Competency Item**	**Item Description**	**Core Competencies of the domain of Natural Science**		
			Elementary School (E)	**Junior High School (J)**	**Upper Secondary School (S-U)**
A **Autonomous Action**	**A1** **Physical and Mental Wellness and Self-Advancement**	Possess the ability to conduct sound physical and mental developments, and maintain an appropriate view of humans and self. Through decision making, analyses, and knowledge acquisition, students can effectively plan their career paths, search for meaning in life, and continually strive for personal growth.	自-E-A1 Be able to use the five senses to observe exquisitely the surrounding environment, maintain curiosity and imagination to continue exploring nature.	自-J-A1 Be able to apply scientific knowledge, methods, and attitudes in daily life.	自 S-U-A1 Understand the progress of science and its contributions and limitations to human society, including scientific careers as one of the options for future career development.
	A2 **Logical Thinking and Problem Solving**	Possess competency in systematic thinking to understand problems, engage in analyses, think critically, and endeavor in meta-thoughts, with the ability to reflect and conduct actions, to	自-E-A2 Be able to use curiosity and imagination, from information or data obtained through observation, reading, and thinking to ask questions or explain data suitable for scientific inquiry. Imagine possibilities of events based on	自-J-A2 Be able to link acquired scientific knowledge with observed natural phenomena and experimental data. Learn to examine evidence by oneself or in groups and respond to multiple viewpoints. In addition, be skeptical	自 S-U-A2 Be able to obtain natural scientific data from a series of observations and experiments. Compare and judge the rationality of scientific data in terms of methods and procedures based on scientific theories, mathematical

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science		
			Elementary School (E)	**Junior High School (J)**	**Upper Secondary School (S-U)**
		effectively tackle and solve problems in daily life.	known scientific knowledge, scientific concepts, and ways of exploring science and understand that there are different arguments, evidence or interpretations for science facts.	about or review credibility of problems, methods, information, or data and put forward possible solutions.	formulas, etc. Further, review the authenticity and credibility of the data with critical arguments. Propose innovative and forward-looking thinking to solve problems.
	A3 **Planning, Execution, Innovation, and Adaptation**	Possess the ability to devise and execute plans, as well as the ability to explore and develop a variety of professional knowledge; enrich life experience and fully utilize creativity to improve one's adaptability to social change.	自-E-A3 Possess the skills of exploring scientific problems through hands-on exploration activities. After considering problem's characteristics and resource availability, be able to formulate simple steps and operate equipment, technological devices, and find resources suitable for the learning stage to conduct natural science experiments.	自-J-A3 Be able to identify problems in daily life, and after considering problem's characteristics and resource, be able to use surrounding objects, equipment, technological devices, and resources in life to plan natural science inquiry activities.	自 S-U-A3 Be able to find research problems from scientific reports or research papers. Based on problems' characteristics, learning resources, desired outcomes, the impact on the society, etc., use instruments and technological equipment suitable for the learning stage. Independently plan comprehensive inquiry & practices activities, and according to the results of experiment, modify the experimental model or innovate and break out the limitation.

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science		
			Elementary School (E)	**Junior High School (J)**	**Upper Secondary School (S-U)**
B **Communication and Interaction**	**B1** **Semiotics and Expression**	Possess the ability to understand and use various types of symbols, including languages, characters, mathematics and science, bodily postures, and arts to communicate and interact with others, and understand and feel empathy for others. Be able to make use of these abilities in daily life or at the workplace.	自-E-B1 Be able to analyze, compare, create charts and graphs, use simple mathematics, and other methods to organize existing natural science knowledge or data. Express the process, findings or results of investigations with simpler forms of spoken words, texts, photos or videos, drawings, physical objects, scientific terms, mathematical formulas, models, etc.	自-J-B1 Be able to summarize, analyze, create charts and graphs, use information, mathematical operations, and other methods to organize natural science knowledge or data. Use spoken words, photos or videos, texts, pictures, drawings or physical objects, scientific terms, mathematical formulas, models, etc., to express the process, findings and results, values, and investigation's limitations.	自 S-U-B1 Be able to adopt rationally thinking skills, make charts and graphs, use information and mathematical operations, and other methods to organize effectively natural scientific information or data. Be able to use spoken words, photos and videos, texts and pictures, drawings or physical objects, scientific terms, mathematical formulas and models, etc., or try to use new media to present, on a larger scale, the relatively rigorous inquiry processes, discoveries or results.
	B2 **Information Technology Literacy and Media Literacy**	Possess the ability to effectively use technology, information, and media of all types, develop competencies related to ethics and media literacy, and develop the ability to analyze, speculate about, and criticize humans' relationships with technology, information, and media.	自-E-B2 Be able to understand how technology and media work. Identify problems or obtain information useful for exploration from learning activities, everyday experiences, and use of technology, natural environment, books, online media, etc.	自-J-B2 Be able to use technological equipment and resources suitable for the learning stage. From learning activities, everyday experience, use of technology, natural environment, books, and online media, develop relevant ethics, discriminate the credibility of information, and conduct various planned observations to obtain information that is conducive to research and problem-solving.	自 S-U-B2 Be able to use appropriately information that is conducive for inquiry, problem-solving, and prediction from everyday experience, use of technology, scientific issues in society, learning activities, natural environment, books, and online media. Then, be able to identify problems or reflect on scientific content in media reports to cultivate a truth-seeking spirit.

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science		
			Elementary School (E)	**Junior High School (J)**	**Upper Secondary School (S-U)**
	B3 **Artistic Appreciation and Aesthetic Literacy**	Possess the abilities of art awareness, creation, and appreciation, experience artistic culture through reflection on arts in daily life, enrich artistic experiences, and develop the ability to appreciate, create, and share arts.	自-E-B3 Observe animals, plants, and natural phenomena in the surrounding environment through five senses and understand how to appreciate beautiful things.	自-J-B3 Appreciate the beauty of nature and life by appreciating the mountains and the earth, wind, clouds, rain and dew, rivers, seas and oceans, and the sun, the moon, and stars.	自 S-U-B3 Learn to appreciate the beauty of science by understanding the simplicity of science theories, the rigor of scientific thinking, and the laws behind complex natural phenomena.
C **Social Participation**	**C1** **Moral Praxis and Citizenship**	Possess competency in putting morality in practice from the personal sphere to the social sphere, and gradually develop a sense of social responsibility and civic consciousness; take the initiative in concern for public topics and actively participate in community events; pay attention to the sustainable development of humanity and the natural environment; and exhibit the qualities of moral character to recognize, appreciate, and practice good deeds.	自-E-C1 Cultivate the caring and action ability to love nature, cherish life and resources.	自-J-C1 From daily learning, take the initiative to care about public issues related to the natural environment and respect life.	自 S-U-C1 Cultivate a sense of social responsibility and civic awareness, which involve caring about environment-related issues. Establish self-awareness that cares for the ecosystem and sustainable human development.

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science		
			Elementary School (E)	**Junior High School (J)**	**Upper Secondary School (S-U)**
	C2 **Interpersonal Relationships and Teamwork**	Possess the competency in exhibiting friendly interpersonal feelings and the ability to establish strong interactive relationships; establish communication channels with others, tolerate outsiders, and participate and serve in social activities and other activities requiring teamwork.	自-E-C2 Through collaborative learning in exploring science, develop the ability to communicate, express, and get along with peers as a team member.	自-J-C2 Through collaborative learning with peers, develop the skills of communicating, participating, conducting, and discovering ~~scientific~~ science-related knowledge and solving problems.	自 S-U-C2 Through group inquiry and discussion, take the initiative to think and debate, communicate and coordinate, listen to different opinions. Have willingness to share inquiry results or help others solve scientific problems.
	C3 **Multi-cultural and Global Understanding**	Stick to one's own cultural identity, respect and appreciate multiculturalism, show active concern for global issues and international situations, demonstrate the ability to adapt to the contemporary world and to social needs, develop international understanding and a multicultural value system, and strive for world peace.	自-E-C3 Through the study of environment-related issues, be able to understand the current status and characteristics of the global natural environment and the cultural differences.	自-J-C3 Through the study of environment-related issues, be able to understand the diversities and interactions of the global natural environment. Develop own cultural identity and values as global citizens.	自 S-U-C3 Be able to take the initiative to care about global environment-related issues, while recognizing that it is the responsibility of global citizens to protect the earth. Develop a world view of multiple values through personal practice.

V. Learning Focus

To fulfil the curriculum goals and basic beliefs of facilitating science competencies, the contents of the essential learning focuses of this domain include: 1. Provide students with the opportunity for inquiry, learning and problem solving, and develop their ability of scientific inquiry. 2. Assist students with understanding how scientific knowledge is produced and cultivate the attitude towards science and nature of science by applying the scientific thinking and inquiry ability. 3. Guide the students learning of the core concepts of scientific knowledge. The cultivation of natural sciences competency, which is part of the holistic development of the 12-Year Basic Education, is achieved by practicing the above contents.

In this domain, "Learning performance" and "Learning content" are deeply intertwined. The former is anticipation regarding the scientific inquiry skills and attitude demonstrated by students when facing science-related questions at different learning stages. The latter denotes the systematic scientific knowledge about the exploration of nature obtained by students at the current stage. It is also a crucial starting point for learning how to solve problems. The natural sciences courses should guide the students learning of scientific inquiry skills and scientific attitude through various methods like inquiry, reading and practice, in order to understand scientific knowledge and to apply what is learned.

Per the varying mental and physical developments of students, the essential learning focuses of the domain of natural sciences are articulated vertically and horizontally across 12-year basic education. (see Table 1: "The natural sciences learning traits of students at different learning stages.") Learning performance includes scientific cognition, inquiry ability, and attitude toward science and the nature of science. (see Table 2: "The framework of learning performance.") The learning content covers three major topics: "Composition and characteristics of the natural world," "Phenomena and the mechanism of the natural world," and "Sustainable development of the natural world." (see Table 3: "The framework of learning content.")

Additionally, "The examples of connecting the essential learning focus of natural sciences domain with core competencies" (see Appendix I) aims to create consistency between the essential learning focuses and core competencies. The essential learning focuses put the core competencies of this domain into practice and guide the cross-domain/subject course design, in order to increase the rigor of course development. Meanwhile, "The guidelines of integrating issues appropriately into domain courses" (see Appendix II) intends to enrich the learning of this

domain and strengthen the cultivation of core competencies. This objective is obtained by interweaving various topics with the essential learning focuses of the natural sciences domain.

Table1. The natural sciences learning traits of students at different learning stages

Learning stage	Description of Cognitive Ability
Stage II	The main goal of the Stage II is to arouse students' interest. The curriculum focuses on observation and personal experiences. Students can explore science topics through imagination and curiosity. And they can initially operate the items and suitable equipment for the learning stage based on the characteristics of the problem for science experiments. Moreover, students can measure and calculate scientific data and describe their findings or outcomes in a simple way.
Stage III	In addition to concrete operational experiences, in Stage III, the curriculum should gradually provide students opportunities to apply thinking skills. Continuing concrete operations, this stage should provide students with the opportunity to read popular science-related articles. Students can present their own opinions or explanations based on observations, readings, and reflections of information or data. And they can preliminarily understand causal relationships based on scientific data, and further understand scientific facts come with corresponding evidence or ways of explanations. Finally, students can express the findings or results in simple forms, using spoken and written texts, images, drawings, models, objects, scientific terms, and so on.
Stage IV	The curriculum of Stage IV moves beyond concrete operations to abstract thinking. Students can perform basic skills of scientific inquiry: asking questions, forming hypotheses, designing simple experiments, collecting data, drawing charts and tables, and presenting evidence and conclusions. Students can learn to identify problems from daily life and make good use of the objects, equipment, technology, and resources around them. In addition, they can collaborate on planning possible steps to take and can conduct scientific inquiry activities to develop basic abilities, such as analysis, assessment and planning, and responsiveness to multiple perspectives. Students can operate technological equipment and resources that are suitable for their learning stage. And they can identify the reliability and legitimate use of information in order to obtain the most pertinent and helpful ones for inquiry and problem solving.
Stage V （Required courses） /(Compulsory)	In the fifth stage (required courses), the curriculum focuses more broadly on the micro-level, computing, and theoretical derivation; also, it establishes a systematic way of thinking with scientific models. Students learn to find problems from daily life experiences, scientific journals, or practical activities. According to factors, such as a problem's characteristics, equipment resources, and expected outcomes, students can use simple scientific models, theories and instruments to conduct scientific inquiry activities, and present appropriate solutions to the problems. Furthermore, students

Learning stage	Description of Cognitive Ability
	can also describe the main features, methods, findings, values, and limitations of scientific activities in a logical way, as well as understand their peers' inquiry process and results through discussions. Finally, students can provide logical explanations or opinions on the results.
Stage V （Enriched elective subjects）/ (Advanced)	In the fifth stage (Enriched elective subjects), the curriculum focuses more broadly on the micro-level, abstract thinking, basic computing, and theoretical derivation; also, it establishes systematic thinking of scientific models and theories. Students can obtain scientific data from a series of observations and experiments. Students compare and judge data based on scientific theories and methods, and then use critical arguments to check the credibility of the data. They propose innovative and prospective thinking to solve problems. Students can also use more complex scientific models, theories, and instruments to plan the complete implementation of inquiry activities independently. And they can reflect on the advantages and disadvantages of the experimental process according to an experiment's results. Finally, they can correct the experimental model or make an innovative breakthrough.

Table2. The framework of learning performance

Items	Sub-Items		Code 1
Scientific cognition	Corresponding to learning content, divided into six levels, including **Remember, Understand, Apply, Analyze, Evaluate, and Create**.		
Inquiry ability	Thinking Ability (t)	Imagination and creativity (i)	ti
		Reasoning and argumentation (r)	tr
		Critical thinking (c)	tc
		Construction of models (m)	tm
	Problem-Solving (p)	Observing and identifying (o)	po
		Planning and executing (e)	pe
		Analyzing and finding (a)	pa
		Discussing and communicating (c)	pc
Attitude towards science and the nature of science	Cultivate interest in scientific inquiry (ai)		ai
	Develop the habit of applying scientific thinking and inquiry (ah)		ah
	Understanding the nature of science (an)		an

Note 1：The codes of learning performanc

1. Code 1：Select the represented English letters of the items and sub-items. For details, see the English letters in bold in the above table. For example, the sub-items: "Imagination and creativity" belong to "Thinking ability," and the code for it is: "ti".
2. Code 2：The second and Stage IIIs (grades 3 to 4 and grades 5 to 6 of the elementary schools stage) are denoted by II and III respectively; the Stage IV (grades 7 to 9, the junior high schools stage) is denoted by IV; The Stage V (grades 10 to 12, the upper secondary schools)

is denoted as follows: Vc means MOE-mandated required courses in senior high school, and Va is Enriched elective subjects in senior high school.

3. Code 3：The Arabic number is the serial number.

Note 2：The scientific cognition at each learning stage is formulated by the instructors, according to the learning content, the students' characteristics and the teaching objectives.

Table3. The framework of learning content

Themes	Cross-subject Concepts	Topics	Sub-Topics
Composition and characteristics of the natural world	Matter and energy (INa)	Composition and characteristics of matter (A)	Composition of matter/materials and periodicity of elements (Aa) Form, properties, and classification of matter/materials (Ab)
		Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba) Temperature and heat (Bb) Energy and metabolism in organisms (Bc) Energy flow and conversion in ecosystems (Bd)
	Structure and function (INb)	Structure and function of matter/materials (C)	Separation and classification of matter/materials (Ca) Structure and function of matter/materials (Cb)
		Structure and function of organisms (D)	Structure and function of cells (Da) Structure and function of plants and animals (Db) Homeostasis and regulation of living organisms (Dc)
	System and scale (INc)	Physical systems (E)	Scales and units of nature (Ea) Force and movement (Eb) Gas (Ec) The universe and celestial bodies (Ed)
		Earth environment (F)	The materials of the Earth (Fa) Earth and space (Fb) Composition of the biosphere (Fc)
Phenomena and the mechanism of the natural world	Change and stability (INd)	Evolution and heredity (G)	Reproduction and inheritance (Ga) Evolution (Gb) Biodiversity (Gc)
		History of the Earth (H)	Origin and evolution of Earth (Ha) Strata and fossils (Hb)
		Dynamic Earth (I)	Changes in the Earth's surface and crust (Ia) Weather and climate change (Ib) Movement of the sea (Ic) Day, night and season (Id)
	Interaction (INe)	Reactions of the materials, equilibrium and production (J)	Law of material reactions (Ja) Changes in aqueous solution (Jb) Oxidation and reduction reactions (Jc) Acid-base reactions (Jd) Chemical reaction rate and equilibrium (Je) Properties, preparation, and reactions of organic compounds (Jf)
		Phenomena and interactions in nature (K)	Waves, light, and sound (Ka) Universal gravitation (Kb) Electromagnetic phenomena (Kc) Quantum phenomena (Kd)

Themes	Cross-subject Concepts	Topics	Sub-Topics
			Basic interactions (Ke)
		Organisms and the environment (L)	Interaction between organisms (La) Interaction between organisms and the environment (Lb)
Sustainable development of the natural world	Science and daily life (INf)	Science, technology, society, and humanities (M)	Relationship between science, technology and society (Ma) History of science development (Mb) Application of science in daily life (Mc) Natural disasters and prevention (Md) Environmental pollution and prevention (Me)
	Resource and sustainability (INg)	Resources and sustainable development (N)	Sustainable development and utilization of resources (Na) Climate change impact and adaptation (Nb) Development and utilization of energy (Nc)

Note：The codes of learning content

1. Code 1：The contents in the elementary schools stage are integrated using an Interdiscipline model, and contain seven interdisciplinary/cross-subject concepts classified as **INa~INg**. Due to the specialization of the sub-division, the junior high schools stage and the senior high schools stage are presented in the topics and sub-topics. The 14 topics are represented by capital letters **A~N**. In the senior high schools stage, the code of the English characters **B**, **P**, **C**, and **E** are added before the subject to represent the contents of the four subjects, such as **B**iology, **P**hysics, **C**hemistry, and **E**arth sciences.
2. Code 2：The second and Stage IIIs (grades 3 to 4,and grades 5 to 6 of elementary schools stage) are denoted by II and III respectively; the Stage IV (grade 7 to 9, junior high schools stage) is denoted by IV; The Stage V (grades 10 to 12, the senior high schools) is denoted as follows: **Vc** means MOE-mandated required courses in senior high school, and **Va** is the Enriched elective subjects in senior high school.
3. Code 3：The Arabic number is the serial number.

1. Elementary School

(1) Learning performance

Items	Sub-Items	Stage II		Stage III	
Inquiry ability -Thinking ability (t)	Imagination and creativity (i)	ti-Ⅱ-1	Students can observe the patterns of daily life phenomena and use their imagination and curiosity for understanding and describe natural	ti-Ⅲ-1	Students can use their curiosity to notice differences in the patterns of everyday phenomena due to certain changes. Students are also able to imagine what might happen based on

Items	Sub-Items	Stage II		Stage III	
			environment phenomena under the teacher's guidance.		known scientific knowledge and the scientific method in order to perceive different methods, and complete different activity tasks.
	Reasoning and argumentation (r)	tr-Ⅱ-1	Students can know that there are reasons for the results of natural phenomena observed and recorded, and can state their ideas based on acquired knowledge.	tr-Ⅲ-1	Students can connect the natural phenomena that they and others have observed and recorded with acquired knowledge. And they can detect each other's relationships, present perceptions and know there are differences with others.
	Critical thinking (c)	tc-Ⅱ-1	Students can easily distinguish or classify the observed natural science phenomena.	tc-Ⅲ-1	Students can make simple records and classify the data or information collected. Moreover, they can think about the correctness of information and identify the differences between information and facts from others based on what they have learned.
	Construction of models (m)	tm-Ⅱ-1	Students can understand simple conceptual models through observing the relationships in natural phenomena, and connect them with real life experiences.	tm-Ⅲ-1	Students can explore the relationships in natural phenomena, establish simple conceptual models, and understand the existence of different models through the process of questioning, observation, and experimentation.
Inquiry ability - Problem-solving (p)	Observing and identifying (o)	po-Ⅱ-1	Students can make observations from daily experiences, learning activities, and the natural environment, and then they are able to become aware of problems.	po-Ⅲ-1	Students are aware of problems from learning activities, daily experiences and technology applications, the natural environment, books, and online media.
		po-Ⅱ-2	Students can ask questions based on observation, data collection, reading, thinking, and discussion.	po-Ⅲ-2	Students can preliminarily identify problems that are suitable for scientific inquiry and can propose appropriate problems for scientific inquiry based on observation, data collection, reading, thinking, and discussion.
	Planning and executing (e)	pe-Ⅱ-1	Students can understand the possible effects of a change in one factor and predict the approximate outcome of the activity.	pe-Ⅲ-1	Students can understand the meaning of independent and dependent variables. They can predict the possible effects of changes and perform the appropriate

Items	Sub-Items	Stage II		Stage III	
					number of experimental operations. Under the guidance or instructions of the teacher or textbook, students can understand the plan of inquiry, and plan simple inquiry activities according to the characteristics of the problem and resources (such as equipment).
		pe-Ⅱ-2	Students can correctly and safely operate items, devices, scientific equipment, and use chemicals suitable for their learning stage. And they can observe and record the experimental process.	pe-Ⅲ-2	Students can correctly, safely operate objects, equipment, technology equipment, and resources appropriate for this learning stage. Students can perform objective qualitative observation or record measured data in detail.
	Analyzing and finding (a)	pa-Ⅱ-1	Students can organize existing information or data by using simple classification, charting, etc.	pa-Ⅲ-1	Students can use simple ways, such as analyzing and comparing, creating charts and tables, and using simple mathematics to organize existing information or data,.
		pa-Ⅱ-2	Students can use the information or data they receive to generate explanations, get answers, and solve problems. And they can compare their own inquiry results with others (e.g., from a teacher) and check if the results are similar or not.	pa-Ⅲ-2	Students can use the information or data they receive to generate explanations, discover new knowledge, learn about cause and effect, solve problems, or discover new problems. And they can compare their own inquiry results with others (e.g., from classmates) and check if the findings are similar or not.
	Discussing and communicating (c)	pc-Ⅱ-1	Students can listen attentively to their classmates' reports, ask questions or make comments. And they can conduct a review of the method, process or outcome of the inquiry.	pc-Ⅲ-1	Students can understand a classmate's report, ask reasonable questions or express opinions. And they can also check the alignments among the “research questions,” “method of inquiry,” “gathered evidence,” and “findings of inquiry” and evaluate and identify the strengths and weaknesses
		pc-Ⅱ-2	Students can use the simple forms of speaking, writing, or drawing to express the	pc-Ⅲ-2	Students can express the process of inquiry, discovery, and results using the simple forms of orals,

Items	Sub-Items	Stage II		Stage III	
			process and findings of inquiry.		texts, or images (for example, photography or video), drawings or objects, scientific terms, mathematical formulas or models.
Attitude towards science and the nature of science (a)	Cultivate interest in scientific inquiry (i)	ai-Ⅱ-1	Students can maintain their curiosity about natural phenomena. They can explore and probe continuously to find new discoveries.	ai-Ⅲ-1	Students can do scientific exploration to understand the reason or mechanism of a phenomenon and satisfy their curiosity.
		ai-Ⅱ-2	Students can explore the pattern of the nature and the physical world, and feel the pleasure of discovering.	ai-Ⅲ-2	Students can feel the pleasure of science learning through the successful experience of scientific exploration.
		ai-Ⅱ-3	Students can enjoy the pleasure of pursuing their own ideas via hands-on practices.	ai-Ⅲ-3	Students can participate in the cooperative learning of an interactive experience with peers, and enjoy the pleasure in science learning.
	Develop the habit of applying scientific thinking and inquiry (h)	ah-Ⅱ-1	Students can understand the characteristic of reality in life by all kinds of sense.	ah-Ⅲ-1	Students can understand the phenomena observed in daily life by using scientific knowledge.
		ah-Ⅱ-2	Students can communicate their opinions and discoveries with others by systematic classification and expression.	ah-Ⅲ-2	Students can solve some of the problems in life through scientific inquiry activities.
	Understanding the nature of science (n)	an-Ⅱ-1	Students can experience that all science inquiry begins with questions.	an-Ⅲ-1	Students can perform scientific inquiry activities to understand that scientific knowledge is based on real experiences and evidence.
		an-Ⅱ-2	Students can perceive that the scientists use different methods to explore the patterns and laws of the natural and material world.	an-Ⅲ-2	Students can perceive that many scientific claims and conclusions will change when the new evidence emerges.
		an-Ⅱ-3	Students can perceive that innovation and imagination are important elements in science.	an-Ⅲ-3	Students can realize that people of different gender, ethnic, and cultural backgrounds can all be scientists.

(2) Learning content

A. Composition and characteristics of the natural world

Topic 1：Composition and characteristics of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
Matter and energy (INa)	INa-Ⅱ-1	The natural world (including biotic and abiotic) is made up of different substances.	INa-Ⅲ-1	Substances are made up of tiny particles, and tiny particles are in constant motion.
	INa-Ⅱ-2	The substances on the Earth have their weight and volume.	INa-Ⅲ-2	Every substance has its own properties; some properties change depending on the temperature
	INa-Ⅱ-3	Matter has characteristics, and it can be classified by its characteristics and applications.	INa-Ⅲ-3	A mixture is made up of different substances. After mixing, the combined weight of the substances does not be change, but the properties of the substances may be change.
	INa-Ⅱ-4	The form of the substances changes depending on the temperature.	INa-Ⅲ-4	Air is composed of various gases that have properties such as thermal expansion and contraction. The gases do not have a specific shape or volume.
	INa-Ⅱ-5	Temperature can be increased by irradiation from the sun, material burning, and rubbing. Temperature can be detected by some metrical methods.	INa-Ⅲ-5	The different forms of energy can be converted to each other, but the total amount of total energy does not change.
	INa-Ⅱ-6	The Sun is the main source of energy for the Earth and provides for some of the growth needs of organisms. The energy can be presented in various forms.	INa-Ⅲ-6	Humans can use energy by transmitting and converting it into electric currents. Students can use equipment such as batteries to store electrical energy and convert it into other energy.
	INa-Ⅱ-7	Organisms need energy (nutrients), sunlight, air, water, and soil to sustain life, growth, and activities.	INa-Ⅲ-7	A moving object has kinetic energy. For an object, the faster its speed, the greater its kinetic energy.

Topic 1：Composition and characteristics of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
	INa-Ⅱ-8	The energy we use commonly in daily life.	INa-Ⅲ-8	Transmission of heat is from high temperature to low temperature through conduction, convection, or radiation. Students can use various methods to insulate and dissipate heat in our life.
			INa-Ⅲ-9	Plants obtain the nutrients needed for growth from sunlight through photosynthesis.
			INa-Ⅲ-10	In the ecosystem, energy flows and circulates between different species via the food chain.
Structure and function (INb)	INb-Ⅱ-1	Matters or objects have different functions or uses.	INb-Ⅲ-1	Substances have different structures and functions.
	INb-Ⅱ-2	The differences in material properties can be used to distinguish or separate substances.	INb-Ⅲ-2	We can separate or identify substances by their characteristics.
	INb-Ⅱ-3	The siphon phenomena can be used to suck the water out of a container. The connecting tube can be used to measure the horizon.	INb-Ⅲ-3	The structure and property of the surface of the materials are different and can generate different frictional forces. The frictional force will affect the movement of the objects.
	INb-Ⅱ-4	The structure and function of the organisms are coordinated with each other.	INb-Ⅲ-4	Force can be transmitted by simple machinery.
	INb-Ⅱ-5	The external morphology of common animals mainly divides into head, trunk, and limbs. But the characteristics and names of the body parts of different animals are different.	INb-Ⅲ-5	Organisms are composed of cells, and can be formed in different levels of organization from cell, to organ, to individual.
	INb-Ⅱ-6	The external morphology of common plants is mainly composed of roots, stems, leaves, flowers, fruits, and seeds.	INb-Ⅲ-6	The morphological characteristics of animals are related to behavior. The structures of animals

Topic 1：Composition and characteristics of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
				are different, and have different ways of movement.
	INb-Ⅱ-7	The external morphology and internal structure of the plants and animals is related to their growth, behavior, reproduction, and adaptation to the environment.	INb-Ⅲ-7	The structure of various parts of plants is related to their function. Some plants produce specialized structures to adapt to the environment.
			INb-Ⅲ-8	Organisms can be classified based on their morphological characteristics
System and scale (INc)	INc-Ⅱ-1	Using tools or custom standards to measure and compare.	INc-Ⅲ-1	Measurement tools and methods are commonly used in life and inquiry.
	INc-Ⅱ-2	Daily use of measurement units and metrics.	INc-Ⅲ-2	The largest or smallest thing (quantity) that is interesting in nature or life. The size of things should be expressed in appropriate units.
	INc-Ⅱ-3	The representation of force, including size, direction, and point of action.	INc-Ⅲ-3	The original amount is different from the amount of change. The degree of change can be evaluated by the ratio of the two.
	INc-Ⅱ-4	Direction and distance can be used to indicate the position of an object.	INc-Ⅲ-4	Multiple measurements of the same thing may have differences between the results. The greater the difference, the less accurate the measurement.
	INc-Ⅱ-5	Force can be transmitted by water and air to move objects.	INc-Ⅲ-5	The magnitude of the force can be known by the degree of change in the state of deformation or the state of motion of an object.
	INc-Ⅱ-6	Water has three phase changes and capillary phenomena.	INc-Ⅲ-6	Time and distance can describe the speed of an object and the changes in its speed.
	INc-Ⅱ-7	Using appropriate tools to observe objects of different sizes and at different distances.	INc-Ⅲ-7	The organ system in an animal is a combination of several organs, which perform a specific

Topic 1：Composition and characteristics of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
				physiological action.
	INc-Ⅱ-8	Different living organisms exist for different environments.	INc-Ⅲ-8	In the same period, a group consisting of the same species in a specific region is called a "population." A group is composed of multiple populations in a specific region that forms a "community."
	INc-Ⅱ-9	The surface on the Earth has different environments, such as rock, sand, and soil. Each has its own characteristics and can be distinguished.	INc-Ⅲ-9	Different environmental conditions affect the species, distribution of organisms, and the relationships of food between organisms, thus forming different ecosystems.
	INc-Ⅱ-10	In the sky, the celestial bodies rise from the east and fall in the west. The moon phases wax and wane. Some stars are bright and some stars are dim.	INc-Ⅲ-10	The Earth is made up of air, land, ocean, and living organisms.
			INc-Ⅲ-11	Rocks are made up of minerals. Rocks and minerals have different characteristics, and each have different uses.
			INc-Ⅲ-12	Water on the Earth exists in the atmosphere, oceans, lakes, and underground.
			INc-Ⅲ-13	The time and location of sunrise and sunset will vary from season to season.
			INc-Ⅲ-14	The starry night in four seasons will be different.
			INc-Ⅲ-15	In addition to the Earth, there are other planets that orbit around the Sun.

B. Phenomena and the mechanism of the natural world

Topic 2：Phenomena and the mechanism of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
Change and stability (INd)	INd-Ⅱ-1	Substances or natural phenomena may change when subjected to the	INd-Ⅲ-1	There are various stable states in nature. If there are new additional factors

Topic 2：Phenomena and the mechanism of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
		effect of external factors. Some changes are fast, and some are slow; some changes can be restored, and some can't.		are added into a stable state, it may change and reach a new stable state.
	INd-Ⅱ-2	The changes in substances or natural phenomena can be detected by using measurement instruments and methods.	INd-Ⅲ-2	Humans can control various factors to influence the changes of substances or natural phenomena. The changing process (before, during, and after) of substances and natural phenomena can be observed. The speed of changing process can be measured and understood.
	INd-Ⅱ-3	Organisms have a certain lifespan from birth and growth to death. Organisms reproduce the next generation through reproduction.	INd-Ⅲ-3	Objects on the Earth (including biotic and abiotic) are subject to the gravity of the Earth. The gravity of the Earth on an object is the weight of that object.
	INd-Ⅱ-4	Wind is produced by airflow.	INd-Ⅲ-4	The traits of an organism between the individuals are different. There are similarities and dissimilarities between the traits of the descendants and parents.
	INd-Ⅱ-5	There are rocks, sand and soil in the natural environment. They will vary due to water flow and wind.	INd-Ⅲ-5	When an organism is stimulated from the environment, it makes an appropriate response and modulates its physiological action automatically to maintain a constant of itself.
	INd-Ⅱ-6	The temperatures in the four-seasons of a year are varied; similarly, the weather in each season is different. We can know the possible changes in weather through weather reports.	INd-Ⅲ-6	There are diversities in the species of organisms. Similarly, there are diversities in the environment of living organisms.

Topic 2：Phenomena and the mechanism of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
	INd-Ⅱ-7	Rainfall, temperature, wind direction, wind speed, and other data are usually used in the weather forecasts to show the weather status. These data are measured by using appropriate instruments.	INd-Ⅲ-7	In a weather chart, the symbols of high/low pressure, weather fronts, and typhoons are used to represent the phenomena of weather and let us recognize the changes in weather.
	INd-Ⅱ-8	There are different forms of force.	INd-Ⅲ-8	The soil is composed of biological remains and debris weathered by rocks. Fossils are the remains of ancient creatures in the strata.
	INd-Ⅱ-9	An object's motion, situation or shape may be changed by force. When objects are deformed by force, some may restore to their original state, and some may not restore.	INd-Ⅲ-9	Sand and soil are eroded, weathered, transported, and deposited by the flowing water, wind, and waves. Rivers are the most important force for changing the Earth's surface.
			INd-Ⅲ-10	Flowing water and activities of organisms would generate different effects on the changes on the Earth's surface
			INd-Ⅲ-11	Changes in weather and climate are affected by the flow of ocean water. When the temperature drops, the water vapor condenses into clouds and fog or sublimates into frost and snow.
			INd-Ⅲ-12	The main process of the water cycle in nature is evaporation of water from the surface of the ocean or lakes, condensation and precipitation, and then transmission back to the oceans or lakes through surface water and groundwater.
			INd-Ⅲ-13	The moving speed of an

Topic 2：Phenomena and the mechanism of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
				object is changed by force. When the object is subjected to multiple forces, it may remain still and maintain the balance. An object can be subjected to the force without contact.
Interaction (INe)	INe-Ⅱ-1	Objects, organisms, and the environment in nature often interact with each other.	INe-Ⅲ-1	There are often rules in the interactions between objects, creatures, and the environment in the natural world.
	INe-Ⅱ-2	The temperature affects the solubility of substances in water (qualitative), and the burning, rusting, and fermentation of substances.	INe-Ⅲ-2	The form and nature of a substance may change or become a new substance due to combustion, rust, fermentation, acid-base action, etc. Some of these changes may be related to temperature, water, air, and light. Changes often happen under some conditions.
	INe-Ⅱ-3	Some substances can dissolve in water, and some do not easily dissolve in water.	INe-Ⅲ-3	Combustion is a phenomenon in which matter and oxygen react violently. Combustion requires combustible substances, combustion aids, and ignition points.
	INe-Ⅱ-4	The acidity and alkalinity of common foods can sometimes be easily distinguished by smell, touch, and taste. Flowers and leaves will change color due to contact with acid or alkali solutions.	INe-Ⅲ-4	The total weight of a substance is constant when dissolved. The total weight of a substance is constant before and after the chemical reaction.
	INe-Ⅱ-5	There are various sounds around life. The vibration of an object produces sound. Students can understand that sound can propagate through solids, liquids, and gases. Different animals make	INe-Ⅲ-5	Students can understand the characteristics of commonly used acidic or alkaline substances. And they can understand the acidity and alkalinity of aqueous solutions and their applications in daily

Topic 2：Phenomena and the mechanism of the natural world				
Cross-subject Concepts	**Stage II**		**Stage III**	
		different sounds and use sound as a means of communication.		life.
	INe-Ⅱ-6	Light moves forward in a straight line and has a certain direction when reflected.	INe-Ⅲ-6	Sounds have different qualities such as volume and high and low and timbre. The sounds in daily life are divided into music and noise, and noise can be prevented.
	INe-Ⅱ-7	A magnet has two poles like poles repel and the unlike poles attract. A magnet attracts objects containing iron. The strength of the magnetic force can be known by the amount of iron-containing material being sucked up.	INe-Ⅲ-7	Sunlight is made up of different colored light.
	INe-Ⅱ-8	Substances can be divided into good and bad electrical conductors. A battery can be connected to a path by using a wire or a good conductor to make a light bulb emit light and rotate a motor.	INe-Ⅲ-8	Light can be refracted. A magnifying glass can focus light into a hot spot or magnify an image.
	INe-Ⅱ-9	Batteries or light bulbs can be connected in series or parallel. The different connections can have different effects.	INe-Ⅲ-9	The Earth has a magnetic field that causes a compass to point in a fixed direction.
	INe-Ⅱ-10	Animals' sensory organs receive external stimuli that cause physiological reactions and behavioral responses.	INe-Ⅲ-10	Both a magnet and an energized wire can generate a magnetic force that can deflect a nearby compass. We can adjust the magnetic pole direction or magnetic force of an electromagnet by changing the direction or magnitude of the current.
	INe-Ⅱ-11	Environmental changes can affect plant growth.	INe-Ⅲ-11	Animals have foraging, reproductive, protective,,

Topic 2： Phenomena and the mechanism of the natural world			
Cross-subject Concepts	**Stage II**	**Stage III**	
			message transmission, and social behaviors.
		INe-Ⅲ-12	The distribution and habits of creatures are affected by environmental factors. Environmental changes can also affect the types of creatures that live in an ecosystem.
		INe-Ⅲ-13	In ecosystems, creatures interact with each other and have parasitic, symbiotic, and competitive relationships.

C. Sustainable development of the natural world

Topic 3： Sustainable development of the natural world				
Cross-subject concepts	**Stage II**		**Stage III**	
Science and daily life (INf)	INf-Ⅱ-1	Common technology products in daily life.	INf-Ⅲ-1	Scientists of different genders, locally and globally, contribute to the advancement of science.
	INf-Ⅱ-2	Different environments affect human life, for example, the type of food, the sources of food, and eating habits.	INf-Ⅲ-2	In daily life, the application of technology will affect the human body and the environment.
	INf-Ⅱ-3	The application and beauty of human life are inspired by the regularities and changes in nature.	INf-Ⅲ-3	The characteristics and scientific principles in nature that apply to and affect our daily lives.
	INf-Ⅱ-4	The relationship between season changes and human life.	INf-Ⅲ-4	In daily life, humans depend on the economic benefits of animals and plants and the methods of cultivation.
	INf-Ⅱ-5	Human activities will affect the environment.	INf-Ⅲ-5	Major natural disasters and disaster prevention and refuge in Taiwan.
	INf-Ⅱ-6	Earthquakes can cause serious disasters; advance preparation and earthquake protection can normally reduce the	INf-Ⅲ-6	In daily life, electrical appliances can generate electromagnetic waves that are functional but can also cause damage.

Topic 3： Sustainable development of the natural world				
Cross-subject concepts	**Stage II**		**Stage III**	
		damage.		
	INf-Ⅱ-7	Water and air pollution can have impacts on living things.		
Resource and sustainability (INg)	INg-Ⅱ-1	There are many resources in the natural environment. The survival and life of humans depend on various resources in the natural environment. Natural resources are limited; we need to cherish them.	INg-Ⅲ-1	It is extremely difficult to recover when the natural landscape and environment are changed or destroyed.
	INg-Ⅱ-2	Making the resources of the Earth sustainable can be achieved with low-carbon and water-saving methods in daily life	INg-Ⅲ-2	The activities of humans and other living things will affect each other. Importing alien species improperly may cause economic loss and ecological damage.
	INg-Ⅱ-3	Methods such as waste reduction, resource recovery, and energy conservation will protect the environment.	INg-Ⅲ-3	Biodiversity is important to humans. The survival of organisms will be influenced by climate change.
			INg-Ⅲ-4	The activities of humans can cause climate change that intensifies the impact on ecology and the environment.
			INg-Ⅲ-5	The use of energy is closely related to the sustainable development of the Earth.
			INg-Ⅲ-6	The meaning of carbon footprint and water footprint in the environment.
			INg-Ⅲ-7	Changes in human behavior can mitigate the impact and effect of climate change.

2. Learning Focuses of Junior High School

(1) Learning performance

Items	Sub-Items	Stage IV

Items	Sub-Items	Stage IV	
Inquiry ability - Thinking Ability (t)	Imagination and creativity (i)	ti-Ⅳ-1	Students can utilize acquired knowledge and concepts of natural sciences, via self or group exploration and discussion, and imagine how the changes in observation or experimental methods may lead to different outcomes. Moreover, under guidance, students can develop new models, products, or outcomes through innovative thinking.
	Reasoning and argumentation (r)	tr-Ⅳ-1	Students can properly connect acquired knowledge to observed natural phenomena and experimental data, in order to make inferences see correlations and justify their arguments.
	Critical thinking (c)	tc-Ⅳ-1	Students can collect and categorize scientific data by themselves and have reasonable conclusions by acquiring the knowledge and concepts of natural sciences. Furthermore, they can offer their own opinions or explanations toward other people's information or reports.
	Construction of models (m)	tm-Ⅳ-1	Students can realize a relatively complex model of nature via experiments and collaborative discussion. Moreover, they can evaluate the advantages and limitations of different models, and apply that further to scientific understanding or in daily life.
Inquiry ability - Problem-solving (p)	Observing and identifying (o)	po-Ⅳ-1	Students can make planned observation and further recognize problems from learning activities, daily experiences, technological application, natural environment, and online media.
		po-Ⅳ-2	Students can judge what problem (or hypothesis) is suitable for scientific inquiry or can be resolved by scientific methods. Further, they can offer proper questions based on their observation, data collection, reading, thinking, and discussion.
	Planning and executing (e)	pe-Ⅳ-1	Students can distinguish various independent variables from dependent variables, plan

Items	Sub-Items	Stage IV	
			appropriate number of experiment trials, and predict possible results. Moreover, under the guidance of teachers or textbooks, students can understand the task at hand and conduct reliable investigations (e.g., multiple trials) according to the characteristics of the question and available resources (e.g., equipment and time).
		pe-Ⅳ-2	Students can accurately and safely operate objects, equipment, and resources that are suitable for this particular learning stage. Students can objectively conduct qualitative observations or quantitative measurements and record them faithfully.
	Analyzing and finding (a)	pa-Ⅳ-1	Students can analyze and generalize, drawing charts and tables, apply methods using information and mathematics, and organize information or data.
		pa-Ⅳ-2	Students can apply scientific principles, thinking intellectual skills, and mathematics to formulate explanations, discover unknown knowledge, obtain causal relations, solve problems, or find new questions from (received) information or data. Meanwhile, they can compare and contrast their investigation results with classmates' results or other relevant information, in order to cross-evaluate and confirm the results.
	Discussing and communicating (c)	pc-Ⅳ-1	Students can understand classmates' inquiry processes and outcomes (or simplified scientific reports), and offer reasonable and justified questions or opinions. Furthermore, students can suggest potential ways of improvement by cross-examining the consistency level among questions, inquiry methods, evidence, and findings.
		pc-Ⅳ-2	Students can utilize verbal, images (e.g., photography, recording), texts and pictures, drawings, concrete objects, scientific terms,

Items	Sub-Items	Stage IV	
			mathematic algorithms, models, reports, or new media approved by teachers, to present their inquiries, findings and outcomes, values, limitations, and claims in detail. Students can summarize the main process, discovery, and potential application as needed.
Attitude towards science and the nature of science (a)	Cultivate interest in scientific inquiry (i)	ai-Ⅳ-1	Students can solve a problem or verify their ideas through hands-on experimentation and achieve a sense of accomplishment in the process.
		ai-Ⅳ-2	Students can share their experiences in science discovered through discussions with peers.
		ai-Ⅳ-3	Students can explain the reasoning of natural phenomena generated through scientific knowledge and various methods of scientific exploration. And they can establish self-confidence in science learning.
	Develop the habit of applying scientific thinking and inquiry (h)	ah-Ⅳ-1	Students can be skeptical of reports about scientific discoveries and even authoritative explanations (for example, reports in newspapers/magazines or explanations in books). And they can evaluate the adequacy and credibility of others' reasoning.
		ah-Ⅳ-2	Students can apply scientific knowledge and scientific inquiry methods they learned to help them make the best decision.
	Understanding the nature of science (n)	an-Ⅳ-1	Students can perceive that the legitimacy of scientific observations, measurements, and methods is governed by socially constructed standards.
		an-Ⅳ-2	Students can distinguish that the certainty and persistence of scientific knowledge will vary depending on the spatiotemporal context of scientific research.

Items	Sub-Items	Stage IV	
		an-Ⅳ-3	Students can perceive that scientists of different genders, backgrounds, and ethnic groups all have the qualities of perseverance, rigor, and logic, as well as curiosity, imagination, and desire to know.

(2) Learning content

A. The learning content of the Junior High Schools Stage

Items	Sub-Items	Stage IV	
Composition and characteristics of matter (A)	Composition of matter/materials and periodicity of elements (Aa)	Aa-Ⅳ-1	The development of atomic models
		Aa-Ⅳ-2	Atomic weight and molecular weight are the relative masses between atoms and molecules.
		Aa-Ⅳ-3	Pure substances include elements and compounds.
		Aa-Ⅳ-4	The properties of the elements have regularity and periodicity.
		Aa-Ⅳ-5	Elements and compounds have specific chemical symbol representations.
	Form, properties, and classification of matter/materials (Ab)	Ab-Ⅳ-1	The particle model of matter and the three states of matter.
		Ab-Ⅳ-2	Temperature affects the state of matter.
		Ab-Ⅳ-3	The physical and chemical properties of matters.
		Ab-Ⅳ-4	Whether matter can be separated by physical methods and can be divided into pure substances and mixtures.
Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba)	Ba-Ⅳ-1	There are different forms of energy, such as kinetic energy, thermal (heat) energy, luminous energy, electrical energy, chemical energy, and so on. They can convert between each other. The total energy of an isolated system will remain constant.
		Ba-Ⅳ-2	Photosynthesis is the process of converting light energy into chemical energy. Cellular respiration is the process of diverting chemical energy into thermal (heat) energy.
		Ba-Ⅳ-3	The change of energy in a chemical reaction often occurs in the form of endothermic or exothermic reactions.
		Ba-Ⅳ-4	A battery is a device that converts chemical energy into electrical energy.
		Ba-Ⅳ-5	Force can lead to work, and work can change the energy of an object.
		Ba-Ⅳ-6	The work done on an object per unit time is called power.

Items	Sub-Items	Stage IV	
		Ba-Ⅳ-7	The sum of the kinetic energy and potential energy of an object is called mechanical energy. Kinetic energy and potential energy can be interchanged.
	Temperature and heat (Bb)	Bb-Ⅳ-1	Heat tends to pass from high temperature to low temperature.
		Bb-Ⅳ-2	A unit of heat is defined as the heat absorbed by the increased temperature of water.
		Bb-Ⅳ-3	After different substances are heated, the temperature changes may be distinctive. Specific heat is a quantitative description of the characteristics listed above.
		Bb-Ⅳ-4	The transmission of heat includes conduction, convection, and radiation.
		Bb-Ⅳ-5	The shape of substances, for example, the differences in states and expansions and contractions in volume may be changed by heat.
	Energy and metabolism in organisms (Bc)	Bc-Ⅳ-1	Metabolism in organisms relies on enzyme catalysis. Exploring the factors that affect the reaction rate of enzymes in a scientific investigation.
		Bc-Ⅳ-2	Cellular respiration releases energy from food (nutrients), which provides for the needs of living organisms.
		Bc-Ⅳ-3	Photosynthesis in plants occurs in chloroplasts that convert carbon dioxide and water into sugar (nutrients) and release oxygen. Nutrients are needed for the plants themselves, and for animals, to grow.
		Bc-Ⅳ-4	Sunlight, carbon dioxide, and water are the factors that affect the progress of photosynthesis. The effects of these factors can be confirmed by experiments.
	Energy flow and conversion in ecosystems (Bd)	Bd-Ⅳ-1	Sunlight is the source of energy in an ecosystem. Energy is transferred among different organisms through food chain interaction within an ecosystem.
		Bd-Ⅳ-2	In an ecosystem, carbon is found in different substances (e.g., carbon dioxide, gluc ose) and is recycled between living and non-li ving things.
		Bd-Ⅳ-3	In an ecosystem, producers, consumers, and decomposers facilitate energy flow and material cycle.
Structure and function of matter/materials (C)	Separation and classification of matter/materials (Ca)	Ca-Ⅳ-1	A mixture is isolated by experiments, for example, crystallization, filtration, and simple filter paper chromatography.

Items	Sub-Items	Stage IV	
		Ca-Ⅳ-2	Compounds can be identified using chemical properties.
	Structure and function of matter/materials (Cb)	Cb-Ⅳ-1	Molecules and atoms
		Cb-Ⅳ-2	Elements have different properties, depending on how the atoms are arranged.
		Cb-Ⅳ-3	The same molecular formula will form different isomers depending on the arrangement of the atoms.
Structure and function of organisms (D)	Structure and function of cells (Da)	Da-Ⅳ-1	The morphology of a cell and its basic structure including cell membrane, cytoplasm, nucleus, and cell wall can be observed by using an appropriate instrument
		Da-Ⅳ-2	A cell is the basic unit of all organisms.
		Da-Ⅳ-3	Multicellular organisms have levels of organization including cells, tissues, organs, and organ systems.
		Da-Ⅳ-4	Cells can undergo cell division. The chromosomes change into different forms during the process of division.
	Structure and function of plants and animals (Db)	Db-Ⅳ-1	Animals (in the case of humans) obtain required nutrients through ingesting, digestion, and absorption.
		Db-Ⅳ-2	The circulatory system of animals (in the case of humans) transports substances to various cells in the body and exchanges' substances. Understanding the operation of the circulatory system through examining heartbeats, heart sounds, and pulse.
		Db-Ⅳ-3	Animals (in the case of humans) exchange gas through the respiratory system.
		Db-Ⅳ-4	The reproductive system (in the case of humans) produces gametes for sexual reproduction. It has the function of secreting hormones.
		Db-Ⅳ-5	The structure of plants and animals adapting to the environment has often become a reference for humans to develop various precision instruments.
		Db-Ⅳ-6	The vascular bundles in roots, stems, leaves, flowers, and fruits of plants have the function of transport.
		Db-Ⅳ-7	In the structure of flowers, the anther of the stamen can produce pollen grains. There are sperm cells in the pollen grains. The ovary in the pistil has ovules. The ovules have egg cells.

Items	Sub-Items	Stage IV	
		Db-Ⅳ-8	The distribution of plants affects not only the flow of water on the Earth's surface but also temperature and air quality.
	Homeostasis and regulation of living organisms (Dc)	Dc-Ⅳ-1	The nervous system of the human body can detect and react to changes in the environment.
		Dc-Ⅳ-2	The endocrine system regulates metabolism and maintains homeostasis.
		Dc-Ⅳ-3	The skin is the first line of immune defense against invading pathogens such as bacteria, while the lymphatic system can further develop an immune response.
		Dc-Ⅳ-4	Through the coordination of various systems, the substances contained in the body and various states can be maintained within a certain range.
		Dc-Ⅳ-5	Organisms can detect changes in the external environment and take appropriate responses to maintain a constant in the in vivo environment. These phenomena can be explored though observing or changing the independent variables.
Physical systems (E)	Scales and units of nature (Ea)	Ea-Ⅳ-1	Time, length, and mass are fundamental physical quantities. Furthermore, the extension of the physical quantities, such as density and volume, can be obtained through calculation.
		Ea-Ⅳ-2	To measure or to estimate physical quantities at an appropriate scale, such as nanometer to light-years, milligrams to metric tons, milliliters to cubic meters, etc.
		Ea-Ⅳ-3	To estimate physical quantity based on the minimum scale of the tool.
	Force and movement (Eb)	Eb-Ⅳ-1	Force can cause an object to move or rotate.
		Eb-Ⅳ-2	Torque can change the rotation of an object. Torque is produced using leverage.
		Eb-Ⅳ-3	The resultant force and the resultant moment of a balanced object are both zero.
		Eb-Ⅳ-4	Friction includes static friction and kinetic friction.
		Eb-Ⅳ-5	The definition of pressure and the Pascal principle.
		Eb-Ⅳ-6	The buoyant force on an object is equal to the weight of the fluid displaced by the object.

Items	Sub-Items	Stage IV	
		Eb-Ⅳ-7	Common uses for simple machines, such as levers, pulleys, axles, gears, and inclined plane, include saving time, effort, or changing the direction of force.
		Eb-Ⅳ-8	When we describe motion, we usually use the concepts of distance, time, and direction.
		Eb-Ⅳ-9	A circular motion is an accelerated motion.
		Eb-Ⅳ-10	A body at rest will remain at rest, and a body in motion will remain in motion unless an external force acts on it.
		Eb-Ⅳ-11	If an object has a net force acting on it, it will accelerate. If the same amount of force is applied to objects with different mass, the object with less mass will have a larger acceleration than an object with greater mass.
		Eb-Ⅳ-12	Mass is the quantity that is solely dependent upon the inertia of an object.
		Eb-Ⅳ-13	For every action, there is an equal and opposite reaction.
	Gas (Ec)	Ec-Ⅳ-1	Atmospheric pressure is caused by the weight of the air in the atmosphere.
		Ec-Ⅳ-2	At constant temperature, there is a qualitative relation between the pressure and volume of fixed amount gas in a closed container.
	The universe and celestial bodies (Ed)	Ed-Ⅳ-1	A Galaxy is a basic unit that constitutes the Universe.
		Ed-Ⅳ-2	The galaxy we are in, called the Milky Way Galaxy, is mainly composed of stars. The Sun is a member of the Milky Way Galaxy.
Earth environment (F)	The materials of the Earth (Fa)	Fa-Ⅳ-1	Earth consists of the systems of atmosphere, hydrosphere, and lithosphere.
		Fa-Ⅳ-2	There are different characteristics and causes of formation between three major types of rock.
		Fa-Ⅳ-3	The main components of the atmosphere are nitrogen and oxygen. Additionally, there are various gases, such as water vapor and carbon dioxide.
		Fa-Ⅳ-4	The atmosphere can become stratified by change in temperature.
		Fa-Ⅳ-5	There are different compositions and characteristics of seawater.

Items	Sub-Items	Stage IV	
	Earth and space (Fb)	Fb-Ⅳ-1	The solar system consists of the Sun and planets. All the planets in the solar system orbit around the Sun.
		Fb-Ⅳ-2	There is a significant difference between the environments of terrestrial planets.
		Fb-Ⅳ-3	The Moon's orbits around the Earth. A solar eclipse or lunar eclipse occurs when the Earth, the Sun, and the Moon are aligned in space.
		Fb-Ⅳ-4	The changing phase of the Moon is regular.
	Composition of the biosphere (Fc)	Fc-Ⅳ-1	The biosphere contains different ecosystems. Concerning the biotic factors, levels of organization of an ecosystem include individuals, populations, and community.
		Fc-Ⅳ-2	A cell is a basic unit that makes up organisms. A cell is composed of molecules, such as carbohydrates, proteins, and lipids. These molecules are composed of smaller particles.
Evolution and heredity (G)	Reproduction and inheritance (Ga)	Ga-Ⅳ-1	The reproduction of organisms can be divided into sexual reproduction and asexual reproduction. The offspring of sexual reproduction has more different traits from their parents than the offspring of asexual reproduction.
		Ga-Ⅳ-2	The sex of a human is mainly determined by sex chromosomes.
		Ga-Ⅳ-3	The ABO blood type of human is a heritable trait.
		Ga-Ⅳ-4	Genetic material will have variation, and its variation may cause changes in traits. If variation occurs in the germ cells, it can be inherited in the offspring.
		Ga-Ⅳ-5	Advances in biotechnology can help solve some problems of agriculture, food, energy, pharmacy, and the environment, but they can also bring new problems.
		Ga-Ⅳ-6	The history of Mendelian genetics.
	Evolution (Gb)	Gb-Ⅳ-1	Evidence from fossils found in the strata indicates that there have been many creatures on the Earth, but some creatures, such as trilobites and dinosaurs, have become extinct.
	Biodiversity (Gc)	Gc-Ⅳ-1	Organisms can be classified according to the characteristics of biological morphology and structure.

Items	Sub-Items	Stage IV	
		Gc-Ⅳ-2	There are many kinds of creatures on the Earth that play different roles in the ecosystem and have different functions to help maintain the stability of the ecosystem.
		Gc-Ⅳ-3	There are many microorganisms on the body's surface and inside the human body, some are beneficial, and some are harmful.
		Gc-Ⅳ-4	In the civilization of humans, there are many examples of the use of microorganisms, such as winemaking and gene transfer.
History of the Earth (H)	Strata and fossils (Hb)	Hb-Ⅳ-1	Studying fossils and lithological characters can help us understand the history of the Earth.
		Hb-Ⅳ-2	Interpreting stratigraphic events and geological events can help us understand the sequence of the development of local stratum.
Dynamic Earth (I)	Changes in the Earth's surface and crust (Ia)	Ia-Ⅳ-1	The effects of external forces and internal forc es will change the landscape.
		Ia-Ⅳ-2	The lithosphere can be divided into several tectonic plates.
		Ia-Ⅳ-3	The plates separate from or collide into each other, and then generate earthquakes, volcanoes, and orogenesis.
		Ia-Ⅳ-4	On the Earth, earthquakes and volcanoes distribute in specific areas, and the two areas are quite consistent.
	Weather and climate change (Ib)	Ib-Ⅳ-1	Air mass is a volume of air with uniform conditions. Each air mass has different properties.
		Ib-Ⅳ-2	The flow of air is caused by the difference between atmospheric pressures. And it will generate wind.
		Ib-Ⅳ-3	The rotation of air with high / low pressure systems is caused by the self-rotation of Earth.
		Ib-Ⅳ-4	A weather front is a boundary separating air masses with different properties, and it will generate types of weather.
		Ib-Ⅳ-5	Disastrous types of weather in Taiwan include typhoons, plum rains (méiyǔ), cold waves, and droughts.
		Ib-Ⅳ-6	In various regions of Taiwan, the effects of southwesterly monsoons in summer and the effects of the northeasterly monsoon in autumn and winter cause seasonal differences in temperature, wind direction, and precipitation.

Items	Sub-Items	Stage IV	
	Movement of the sea (Ic)	Ic-Ⅳ-1	The movements of the ocean include waves, currents, and tides; each movement has different mode.
		Ic-Ⅳ-2	Ocean current can affect the climate of the land.
		Ic-Ⅳ-3	Ocean currents around Taiwan vary depending on the seasons.
		Ic-Ⅳ-4	The variations of tides are regular.
	Day, night and season (Id)	Id-Ⅳ-1	Daytime in the summer is longer than in the winter, and nighttime in the winter is longer than in the summer.
		Id-Ⅳ-2	Change in the angle of sunlight causes differences in the amount of solar energy absorbed per unit area ~~on~~ of the Earth's surface.
		Id-Ⅳ-3	The main cause of the four seasons on the Earth is that the Earth's axis of rotation is tilted with respect to its orbital plane.
Reactions of the materials, equilibrium and production (J)	Law of material reactions (Ja)	Ja-Ⅳ-1	The law of conservation of mass in chemical reactions.
		Ja-Ⅳ-2	A chemical reaction is a rearrangement of atoms.
		Ja-Ⅳ-3	Chemical reactions are often accompanied by precipitation, gas, and changes in color, and temperature.
		Ja-Ⅳ-4	The representation of chemical reactions.
	Changes in aqueous solution (Jb)	Jb-Ⅳ-1	Experiments conducted on an aqueous solution to understand electrolytes and non-electrolytes.
		Jb-Ⅳ-2	Electrolytes can conduct electricity in an aqueous solution because it can be dissociated into anions and cations.
		Jb-Ⅳ-3	Reactions in aqueous solutions include: precipitation of different ions, acid-base neutralization, and redox reactions.
		Jb-Ⅳ-4	The concentration of solutions can be represented by different concepts: weight-volume percentage (w/v %) and parts per million (ppm).
	Oxidation and reduction reactions (Jc)	Jc-Ⅳ-1	The narrow definition of an oxidation reaction is that a substance gains oxygen; this is called an oxidation reaction. The loss of oxygen is called a reduction reaction.
		Jc-Ⅳ-2	A material combustion experiment recognizes oxidation.
		Jc-Ⅳ-3	Combustion experiments on different metal elements recognize the activity of those elements with oxygen.
		Jc-Ⅳ-4	Oxidation-reduction reactions and their

Items	Sub-Items	Stage IV	
			applications in daily life.
		Jc-Ⅳ-5	A zinc-copper battery experiment to understand the battery principle.
		Jc-Ⅳ-6	The discharging and charging of chemical batteries.
		Jc-Ⅳ-7	The principle of electrolysis through experiments with electrolytic water and a copper sulfate aqueous solution.
	Acid-base reactions (Jd)	Jd-Ⅳ-1	When metal oxide compounds and non-metal oxide compounds dissolve into aqueous solutions they produce acidity and alkalinity. Acidic solutions react with metal and marble.
		Jd-Ⅳ-2	The relationship between acid-base and pH.
		Jd-Ⅳ-3	Understanding universal indicators and pH meters by doing experiments.
		Jd-Ⅳ-4	The relationship between hydrogen ions and hydroxide ions in an aqueous solution.
		Jd-Ⅳ-5	Applications and dangers of acids, alkalis, and salts in daily life.
		Jd-Ⅳ-6	Through experiments, students recognize that acid-base neutralization forms salt and water. The reaction can release heat to change the temperature.
	Chemical reaction rate and equilibrium (Je)	Je-Ⅳ-1	Experimental understanding of chemical reaction rates and the factors that affect them, such as the nature of compounds, temperature, concentration, contact area and catalysts.
		Je-Ⅳ-2	Reversible reactions.
		Je-Ⅳ-3	Chemical reactions are equilibrium reactions. Changes in concentration, temperature and pressure can affect chemical equilibrium.
	Properties, preparation, and reaction of organic compounds (Jf)	Jf-Ⅳ-1	The essential features of organic compounds and inorganic compounds.
		Jf-Ⅳ-2	Compounds are found in common life, such as alkanes, alcohols, organic acids and esters.
		Jf-Ⅳ-3	Esterification and saponification reactions.
		Jf-Ⅳ-4	The properties of common plastic.
Phenomena and interactions in nature (K)	Waves, light, and sound (Ka)	Ka-Ⅳ-1	The characteristics of waves such as crest, trough, wavelength, frequency, wave speed, and amplitude.
		Ka-Ⅳ-2	Waves can propagate as longitudinal waves and transverse waves.
		Ka-Ⅳ-3	Factors, such as medium, state, density, and temperature, affect the speed of sound.
		Ka-Ⅳ-4	The reflection of sound waves can be used for measurements and propagation.
		Ka-Ⅳ-5	Ears can distinguish different sounds by pitch, loudness, and tone. Humans cannot hear ultrasound.

Items	Sub-Items	Stage IV	
		Ka-Ⅳ-6	Verify and explain that light travels in a straight line by using pinhole imaging and shadows.
		Ka-Ⅳ-7	The speed of light and the factors that affect the speed of light.
		Ka-Ⅳ-8	Explore the reflection and refraction of light through experiments.
		Ka-Ⅳ-9	There are many examples of instruments that use optical principles in daily life, such as lenses, mirrors, eyes, glasses, and microscopes.
		Ka-Ⅳ-10	Sunlight can be dispersed into its spectral components by using triangular prisms.
		Ka-Ⅳ-11	Nearly all colors of objects are due to selective reflection and absorption of light.
	Universal gravitation（Kb）	Kb-Ⅳ-1	Think of mass as the amount of material that makes up your body, then your weight is the force of the universal gravitation of the Earth (or whatever planet or satellite you are standing upon) on the mass of your body.
		Kb-Ⅳ-2	Every particle attracts every other particle in the universe with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.
	Electromagnetic phenomena（Kc）	Kc-Ⅳ-1	Objects can become negatively or positively charged when friction results in the transfer of electrons between objects.
		Kc-Ⅳ-2	The electric force for charges at rest has the following properties: like charges repel each other; unlike charges attract each other.
		Kc-Ⅳ-3	Magnetic field lines are visual tools used to represent magnetic fields. They describe the direction of magnetic fields. Magnetic fields are stronger, where the lines are denser.
		Kc-Ⅳ-4	The right-hand rule for a wire is: point your thumb in the direction of the current, then wrap your fingers around the wire, and your fingers are curled in the same direction of the magnetic field.
		Kc-Ⅳ-5	When a current carrying conductor is exposed to another magnetic field, they exert forces upon each other. Introduce the principle of the motor.
		Kc-Ⅳ-6	A changing magnetic field through a coil of wire will induce a current.

Items	Sub-Items	Stage IV	
		Kc-Ⅳ-7	The potential difference between two points is directly proportional to the current through the conductor, and the resistance is inversely proportional to the current.
		Kc-Ⅳ-8	A resistor dissipates energy in the form of heat.
Organisms and the environment (L)	Interaction between organisms (La)	La-Ⅳ-1	The structure of an ecosystem changes over time along with the interaction between organisms and the environment, and a results in succession.
	Interaction between organisms and the environment (Lb)	Lb-Ⅳ-1	Abiotic factors in the ecosystem may affect the distribution and survival of organisms. Environmental surveys are often needed to detect changes in abiotic factors.
		Lb-Ⅳ-2	Human activities can lead to change in the environment and may also affect the survival of other organisms.
		Lb-Ⅳ-3	Humans can take action to maintain the living environment of others organisms. Humans must enable other organisms to grow, reproduce and interact in the environment in order to maintain ecological balance.
Science, technology, society, and humanities (M)	Relationship between science, technology and society (Ma)	Ma-Ⅳ-1	Advances in biology help to solve the problems of agriculture, food, energy, medicine, and the environment that occur in our society.
		Ma-Ⅳ-2	Conservation is not something that scientists can deal with by themselves. All citizens have the right and obligation to join in studies of, to monitor and to maintain biodiversity.
		Ma-Ⅳ-3	The impact of different materials used in life and society.
		Ma-Ⅳ-4	The impact of various methods of power generation and energy technology on society, ecology, the environment, and the economy.
		Ma-Ⅳ-5	The enlightenment of local scientific knowledge (including aboriginal sciences and worldviews) on the social, economic environment-related issues, and ecological protection.
	History of science development (Mb)	Mb-Ⅳ-1	The development of biotechnology has adapted to the needs of human beings, using cross-disciplinary techniques to transform organisms. In the process of developing related technologies, excessive influence on other organisms and the environment should be avoided.

Items	Sub-Items	Stage IV	
		Mb-Ⅳ-2	The process of important discoveries in science history, as well as the contributions from people of different genders, backgrounds, and ethnic groups.
	Application of science in daily life (Mc)	Mc-Ⅳ-1	The effects of environmental pollutants on the growth conditions and mechanisms of organisms.
		Mc-Ⅳ-2	Knowledge about the structure and function of organisms can be applied to improve human life.
		Mc-Ⅳ-3	The process and applications of various materials in life.
		Mc-Ⅳ-4	The characteristics of common artificial materials, as well as simple manufacturing processes and their applications in life.
		Mc-Ⅳ-5	A summary of power supplies and delivery methods.
		Mc-Ⅳ-6	Students should have knowledge of how to safely use electricity and how to avoid electrical shocks and prevent wire fires.
		Mc-Ⅳ-7	Students should have knowledge of electrical indications and the calculation of the electricity fees.
	Natural disasters and prevention (Md)	Md-Ⅳ-1	The application of bio-conservation knowledge and skills in the prevention of natural disasters.
		Md-Ⅳ-2	Typhoons mainly occur from July to September and often cause loss of life and property.
		Md-Ⅳ-3	Typhoons bring disasters, such as gusty winds, heavy rains, and tidal waves.
		Md-Ⅳ-4	Taiwan is at the junction of tectonic plates, so earthquakes are frequent and often causes disasters.
		Md-Ⅳ-5	Along with the dip direction of slope, heavy rainfall will increase the threat of landslides.
	Environmental pollution and prevention (Me)	Me-Ⅳ-1	The impact and application of environmental pollutants on the growth of organisms.
		Me-Ⅳ-2	The reuse of domestic wastewater and resulting impacts.
		Me-Ⅳ-3	The types and sources of air pollution and the general control methods of air quality.
		Me-Ⅳ-4	The effects of greenhouse gases and global warming.
		Me-Ⅳ-5	The impact of heavy metal pollution.
		Me-Ⅳ-6	The relationship between environmental pollutants and biomagnification.
		Me-Ⅳ-7	In-depth research on the characteristics of sound can help us to prevent noise pollution.
Resources and	Sustainable development	Na-Ⅳ-1	The use of biological resources affects the

Items	Sub-Items	Stage IV	
sustainable development (N)	and utilization of resources (Na)		interdependence of organisms.
		Na-Ⅳ-2	The main methods on how to save energy in daily life.
		Na-Ⅳ-3	Environmental quality is based on sustainable use of resources and maintenance of ecological balance.
		Na-Ⅳ-4	5Rs in resources represent **R**eduction, **R**ejection, **R**euse, **R**ecycling, and **R**egeneration.
		Na-Ⅳ-5	The impact of various types of waste on the environment, such as the carrying capacity of the environment and approaches to waste management.
		Na-Ⅳ-6	The development of human society is be based on the environmental protection of the Earth.
		Na-Ⅳ-7	In order to make the Earth more sustainable, we can start employing the methods of reduction, recycling, reuse, and green energy.
	Climate change impact and adaptation (Nb)	Nb-Ⅳ-1	The impact of global warming on organisms.
		Nb-Ⅳ-2	The impact of climate change includes sea-level rise, global warming, and abnormal precipitation.
		Nb-Ⅳ-3	The methods for responding to climate change are mitigation and adaptation.
	Development and utilization of energy (Nc)	Nc-Ⅳ-1	The current status of the development of biomass energy.
		Nc-Ⅳ-2	There are risks in the development of energy; we should evaluate and decide what to do according to the evidence.
		Nc-Ⅳ-3	The formation and characteristics of fossil fuels.
		Nc-Ⅳ-4	The development of emerging energy sources, such as wind energy, solar energy, nuclear power generation, steam, electricity symbiosis, biomass energy, fuel cells, and so on.
		Nc-Ⅳ-5	The technologies of emerging energy, such as hybrid-electric vehicles and solar aircraft.
		Nc-Ⅳ-6	The current situation and future prospects of Taiwan's energy use.

B. The cross-subject themes of the natural sciences

(a) Cross-subject Theme: From the Atom to the Universe

Subtopic	Learning Content	
Scales and units of nature (Ea) **Structure and function of cells (Da)** Composition of the biosphere (Fc) Earth and space (Fb)	INc-Ⅳ-1	The scales of objects and events in the universe can be divided into the microscopic scales and the macroscopic scales.
	INc-Ⅳ-2	Corresponding to different scales, there are suitable units (for example, the unit of length). The size of the scale can be expressed by scientific notation.
	INc-Ⅳ-3	The need to choose the appropriate scale when making measurements.
	INc-Ⅳ-4	The relationship between the different scales of objects can be presented in a proportion.
	INc-Ⅳ-5	In the microscopic scales, the living world and the material world are made up of atoms and molecules.
	INc-Ⅳ-6	In the macroscopic scales, the world is made up from individuals to the biosphere.

(b) Cross-subject Theme: Forms of Energy

Subtopic	Learning Content	
Form and conversion of energy (Ba) Temperature and heat (Bb) Energy and metabolism in living organisms (Bc) Energy flow and conversion in ecosystems (Bd) Relationship between science, technology and society (Ma) Application of science in daily life (Mc) Sustainable development and utilization of resources (Na) Development and utilization of energy (Nc)	INa-Ⅳ-1	There are many different forms of energy.
	INa-Ⅳ-2	Energy can be converted between each other, and be maintained at a fixed amount.
	INa-Ⅳ-3	Scientific discoveries and new energy sources and their impact on daily life and society.
	INa-Ⅳ-4	The characteristics and effects of various energy sources in daily life.
	INa-Ⅳ-5	The development, utilization, and sustainability of energy sources.

(c) Cross-subject Theme: Global Climate Change and Adaptation

Subtopic	Learning Content	
Form and conversion of energy (Ba) Temperature and heat (Bb) Energy flow and conversion in ecosystems (Bd) Interaction between organisms and the environment (Lb) Relationship between science, technology and society (Ma) Environmental pollution and prevention (Me) Climate change impact and adaptation (Nb)	INg-Ⅳ-1	The main source of energy for the various systems on the Earth is the Sun. There are transmissions of energy between these various systems.
	INg-Ⅳ-2	Some of the variable gases in the atmosphere are greenhouse gases.
	INg-Ⅳ-3	When substances are heated, the change in temperature of different substances may be different.
	INg-Ⅳ-4	The storage and flow of carbon in nature.

Subtopic	Learning Content	
	INg-Ⅳ-5	The environment is changed by the activities of living creatures, and the activities of living creatures are affected by environmental changes.
	INg-Ⅳ-6	The impact of the development of new technologies on the natural environment.
	INg-Ⅳ-7	The relation between greenhouse gases and global warming.
	INg-Ⅳ-8	The impact generated by climate change is global.
	INg-Ⅳ-9	Mitigation and adaptation are the two main methods used to respond to climate change.

3. MOE-mandated Required Courses at Upper Secondary School

(1) Learning performance

Items	Sub-Items	Stage V (MOE-mandated required courses)	
Inquiry ability – Thinking ability (t)	Imagination and creativity (i)	ti-Ⅴc-1	Students become conscious of the causes of different questions of natural sciences in daily life. And they can provide various hypothetical solutions based on their scientific knowledge. Furthermore, individually or in groups, students can offer innovative ways of scientific exploration and get results.
	Reasoning and argumentation (r)	tr-Ⅴc-1	Students can apply simple mathematic algorithm and single scientific evidence or theories, apprehend scientific knowledge or theories and causal relations, identify the limitations in another person's argument and offer different opinions.
	Critical thinking (c)	tc-Ⅴc-1	Students can compare and judge the rationality of methods and procedures between themselves and other people's interpretations of scientific data. They can ask questions or offer opinions.
	Construction of models (m)	tm-Ⅴc-1	Students can build models from scientific questions by thinking by themselves or through group discussion. In addition, students can use methods such as analogy or abstraction to describe a systematic scientific phenomenon, and to understand the limitations of a model.
Inquiry ability -	Observing and	po-Ⅴc-1	Students can obtain information from daily

Items	Sub-Items	Stage V (MOE-mandated required courses)	
Problem-solving (p)	identifying (o)		experiences, use of technology, science-related social issues, learning activities, the natural environment, as well as traditional and online media. And they can observe in a planned and organized manner to identify problems.
		po-Ⅴc-2	Students can confirm and ask questions (or make hypotheses) that are suitable for scientific exploration or can be resolved by scientific approaches based on observation, data collection, reading, thinking, and discussion. Furthermore, students can distinguish and prioritize important questions (or hypotheses) between different problems.
	Planning and executing (e)	pe-Ⅴc-1	Students can distinguish several independent or dependent variables, plan the numbers of tests properly, reasonably predict potential outcomes for activities, and identify possible causes for failure. Under the guidance of textbooks or teachers or through their own creativity, students can plan an optimized practical (or reasoning) inquiry activity or problem-solving activity, in accordance with elements like the characteristics of questions, learning resources (equipment, time, and human resources), expected outcomes (including reliability and validity), and impacts on the social environment.
		pe-Ⅴc-2	Students can correctly and safely operate objects, equipment, technological instruments, and resources appropriate for this learning stage, as well as adjust the executing process if needed. Students can accurately conduct qualitative observation or quantitative measurement and use technological instruments to assist with record taking when required.
	Analyzing and finding (a)	pa-Ⅴc-1	Students can reasonably use thinking skills, charts, tables, information, and mathematics to effectively organize information or data.
		pa-Ⅴc-2	Students can apply scientific principles, thinking skills, mathematics, and statistics to examine information or data gathered from inquiry, to articulate explanations,

Items	Sub-Items	Stage V (MOE-mandated required courses)	
			understanding, new knowledge, causal relations, or comprehend science-related social issues, resolve problems, or discover new questions. Furthermore, they can compare their findings with other classmates' outcomes or other relevant information and cross-examine and confirm the results.
	Discussing and communicating (c)	pc-V c-1	Students can understand classmates' inquiry processes and outcomes (or simplified scientific reports), and provide reasonable and relatively complete questions or opinions. Students can evaluate the whole inquiry procedure, including observation, question defining, reasoning and practice, the reliability and validity of data, resource utilization, activity safety, and inquiry outcome. They can further check quality, make evaluation, and suggest reasonable improvements.
		pc-V c-2	Students can use oral, images (e.g., photography, filming), texts and pictures, drawings, real objects, scientific terms, mathematic formulas, and models, to present their inquiry process, findings, or results. Without revealing personal information and undermining the public interest, students can report or employ new media to autonomously and comprehensively share their relatively rigorous inquiry findings, outcomes, conclusions, or claims. Moreover, they can summarize the objectives, characteristics, methods, findings, values, restrictions, applications, and prospects of their inquiry when needed.
Attitude towards science and the nature of science (a)	Cultivate interest in scientific inquiry (i)	ai-V c-1	Students can acquire a sense of accomplishment by successful problem-solving experiences.
		ai-V c-2	Students can generate new experiences and interests by scientific exploration and thinking of things from their surroundings.
		ai-V c-3	Students can appreciate the importance of science through experiencing the application of science everywhere in daily life.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
	Develop the habit of applying scientific thinking and inquiry (h)	ah-V c-1	Students can know that scientific knowledge is an explanation for people to understand phenomena, but it is not the only explanation.
		ah-V c-2	Students can keep a critical attitude towards scientific information obtained in daily life and carefully examine its authenticity and credibility.
	Understanding the nature of science (n)	an-V c-1	Students can understand how to use a variety of methods, tools, and techniques for different dimensions of evidence during the scientific inquiry process in order to support specific interpretations that enhance the validity of scientific arguments.
		an-V c-2	Students can understand that the way of knowing in science requires empirical evidence, logical thinking, skepticism, and repeated reviewing.
		an-V c-3	Students can realize that science can help humans create better-living conditions, but it cannot solve all the problems in human society. Technology development may sometimes cause environmental or ethical issues.

(2) Learning content

A. Biology

Items	Sub-Items	Stage V (MOE-mandated required courses)	
Structure and function of organisms (D)	Structure and function of cells (Da)	BDa-V c-1	Different cells have different functions, morphologies, and structures.
		BDa-V c-2	Structure and function of prokaryotic cells and eukaryotic cells.
		BDa-V c-3	ATP is a direct source of energy, which provides fuel for cellular physiology.
		BDa-V c-4	The energy transformation between photosynthesis and respiration.
		BDa-V c-5	The cell cycle of eukaryotic cells includes interphase and cell division.
		BDa-V c-6	The cell division of eukaryotic cells.
		BDa-V c-7	The process of mitosis.
		BDa-V c-8	Animal germ cells generally undergo a process of meiosis to form gametes.
		BDa-V c-9	A fertilized egg of multicellular organisms produces different types of cells via the process of mitosis and cell differentiation.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
Evolution and heredity (G)	Reproduction and inheritance (Ga)	BGa-V c-1	The relationship between heritable traits and factors according to the Mendel's Law of Heredity.
		BGa-V c-2	Extension of the principles of Mendelian inheritance.
		BGa-V c-3	Development of the chromosome theory of inheritance.
		BGa-V c-4	Sex-linked inheritance.
		BGa-V c-5	Nucleic acid is the carrier of the genetic information.
		BGa-V c-6	The central dogma of molecular genetics.
		BGa-V c-7	Same characters can have different traits.
	Evolution (Gb)	BGb-V c-1	The proportion of traits of biological character traits can vary.
		BGb-V c-2	Darwin's theory of evolution.
		BGb-V c-3	The impact of the concept of common descent on biological taxonomy.
		BGb-V c-4	The impact of evolutionary evidence on the evolution of the taxonomic scheme.
		BGb-V c-5	Current biodiversity is formed by the evolution of organisms on the Earth.
Science, technology, society, and humanities (M)	History of science development (Mb)	BMb-V c-1	The history of cell theory.
		BMb-V c-2	Gregor Mendel infers the laws of inheritance based on experimental results.
		BMb-V c-3	The discovery of sex chromosomes.
		BMb-V c-4	The formation and development of evolutionary concepts.
	Application of science in daily life (Mc)	BMc-V c-1	The application of gene transfer techniques.

B. Physics

Items	Sub-Items	Stage V (MOE-mandated required courses)	
Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba)	PBa-V c-1	Both electric and magnetic (EM) fields have energy. Sending messages by mobile phone is an example of EM fields transmitting energy in the form of electromagnetic waves.
		PBa-V c-2	Energy can change in form but the total amount of energy is conserved. The form of energy can have various display and descriptions due to observation in different scales.
		PBa-V c-3	Mass can be transformed into energy and vice versa. The equivalence equation is $E = mc^2$.
		PBa-V c-4	Fusion and fission are applications of mass-energy equivalence and are currently an important energy issue.
	Temperature and heat （Bb）	PBb-V c-1	A brief description of the meaning of the Kelvin temperature scale and the internal energy of an ideal gas.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
		PBb-Ⅴc-2	All experiments indicate that work can be easily transformed into heat, but heat cannot be completely transformed into work.
		PBb-Ⅴc-3	The atoms in an object are constantly in motion and interacting with each other. The thermal energy of an object is the sum of all interaction energy and kinetic energy of the atoms composing the object.
		PBb-Ⅴc-4	Heat is the energy transfer during thermal contact of two objects with different temperatures.
Physical systems (E)	Scales and units of nature（Ea）	PEa-Ⅴc-1	The International System of Units is a widely used system of measurement in science.
		PEa-Ⅴc-2	Due to the limitation of tools and convenience of applications, many scientific measurements and physical quantities are derived from standard measurements of basic physical quantities.
		PEa-Ⅴc-3	The diameter of an atom is of the order of 10^{-10} m, whereas the diameter of the nucleus is roughly 10^{-15} m.
	Force and movement (Eb)	PEb-Ⅴc-1	The observation of and speculation on the motion of objects by scholars before Galileo.
		PEb-Ⅴc-2	The course of Galileo's research and speculation on the motion of objects.
		PEb-Ⅴc-3	The historical background and content of Kepler's three laws of planetary motion.
		PEb-Ⅴc-4	Newton's Laws of Motion
		PEb-Ⅴc-5	Common forces such as friction, normal force, and elastic force.
Phenomena and interactions in nature (K)	Waves, light, and sound (Ka)	PKa-Ⅴc-1	The mathematical equations relating wave speed, frequency, and wavelength.
		PKa-Ⅴc-2	Qualitative introduction to the Doppler effect and its application.
		PKa-Ⅴc-3	Corpuscular theory and wave theory are major theories of light in history.
		PKa-Ⅴc-4	Law of reflection of light. Explanation of the law of refraction of light with wave theory.
		PKa-Ⅴc-5	In addition to reflection and refraction, the phenomena of light also include interference and diffraction.
		PKa-Ⅴc-6	Huygens' principle can be used to describe how light waves move: straightforward movement, interference, and diffraction.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
		PKa-Ⅴc-7	Maxwell equations predict the existence of electromagnetic waves propagating at the speed of light. The result that light is an EM wave was later confirmed in experiments.
	Universal gravitation（Kb）	PKb-Ⅴc-1	Kepler's Laws of Planetary Motion are explained by Newton's Laws of Motion and Universal Gravitation.
		PKb-Ⅴc-2	Qualitative description of the motion of an object in gravitational field.
	Electromagnetic phenomena（Kc）	PKc-Ⅴc-1	Electric charges induce electric fields. The magnitude of the electric force between two charged particles is proportional to the product of the charges of the two charged particles and inversely proportional to the square of the distance between them.
		PKc-Ⅴc-2	Negatively charged electrons and a positively charged nucleus are attracted to each other by electric force and form stable structure.
		PKc-Ⅴc-3	A time-varying magnetic field induces an electric field and a time-varying electric field induces a magnetic field.
		PKc-Ⅴc-4	All electromagnetic phenomena after integration can be described by Maxwell's equations.
		PKc-Ⅴc-5	Maxwell's equations predict that a perturbed electromagnetic field can propagate in space as electromagnetic waves.
		PKc-Ⅴc-6	Electromagnetic waves, from low frequency (radio waves) to high frequency (gamma rays), are widely used in daily life.
	Quantum phenomena（Kd）	PKd-Ⅴc-1	Light has properties of particles. Light’s photon energy ($E=hv$) is proportional to its frequency (v).
		PKd-Ⅴc-2	The application of the photoelectric effect in daily life.
		PKd-Ⅴc-3	Atomic spectrum.
		PKd-Ⅴc-4	The concept of energy levels.
		PKd-Ⅴc-5	Double-slit experiment and wave properties of electrons.
		PKd-Ⅴc-6	Particle-wave duality applies to electrons, photons and all microscopic particles.
		PKd-Ⅴc-7	Newton's law cannot be applied to the physics at an atomic scale.
	Basic interactions (Ke)	PKe-Ⅴc-1	Protons and neutrons are held together in a nucleus of an atom by a strong force.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
		PKe-Ⅴc-2	An isolated neutron is unstable. It will decay into a proton and other particles through weak interaction (or the weak force).
		PKe-Ⅴc-3	The four fundamental interactions of nature are the gravitational force, the electromagnetic force, the weak force, and the strong force.
Science, technology, society, and humanities（M）	Application of science in daily life（Mc）	PMc-Ⅴc-1	Electrical safety.
		PMc-Ⅴc-2	The application of electricity in life.
		PMc-Ⅴc-3	Scientific attitudes and methods.
		PMc-Ⅴc-4	The development of modern physical science and the contributions of scientists from different genders, backgrounds, and ethnic groups.
Resources and sustainable development (N)	Development and utilization of energy (Nc)	PNc-Ⅴc-1	Nuclear fission
		PNc-Ⅴc-2	Nuclear power and radiation protection.
		PNc-Ⅴc-3	For systems with the same energy, the ability to do work is not necessarily the same.
		PNc-Ⅴc-4	Although energy is conserved, the efficiency of doing work will be reduced when energy is converted from one form to another.

C. Chemistry

Items	Sub-Items	Stage V (MOE-mandated required courses)	
Composition and characteristics of matter (A)	Composition of matter/materials and periodicity of elements (Aa)	CAa-Vc-1	Lavoisier proposed that the most basic components of matter are the elements.
		CAa-Vc-2	Dalton proposed atomic theory according to the Law of Definite Proportions, the Law of Multiple Proportions, the Law of Conservation of Mass, and the concept of an element.
		CAa-Vc-3	The elements are arranged on the Periodic Table according to their atomic numbers.
		CAa-Vc-4	Isotopes.
	Form, properties, and classification of matter/materials (Ab)	CAb-Vc-1	The three-phase diagram of a substance.
		CAb-Vc-2	Elements can be classified into metals, metalloids, and nonmetals according to their characteristics.
		CAb-Vc-3	Chemical compounds can be classified into ionic compounds and molecular compounds depending on their composition and properties.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba)	CBa-Vc-1	After the chemical reaction occurs, if the sum of the energy of the product is lower than that of the reactant, it is an exothermic reaction; if the opposite occurs, it is an endothermic reaction.
		CBa-Vc-2	The energy conversion process follows energy conservation.
Structure and function of matter/materials (C)	Separation and classification of matter/materials (Ca)	CCa-Vc-1	Separation processes and purification methods of mixtures: distillation, extraction, chromatography, hard water softening, and seawater purification.
		CCa-Vc-2	The difference in compound properties.
	Structure and function of matter/materials (Cb)	CCb-Vc-1	Different chemical bonds are formed between atoms in different ways.
		CCb-Vc-2	The properties of a chemical bond affect the structure of the substance and determine its functions.
Physical systems (E)	Gas (Ec)	CEc-Vc-1	The basic properties of a gas.
Reactions of the materials, equilibrium and production (J)	Law of material reactions (Ja)	CJa-Vc-1	Lavoisier used quantitative analysis to verify the law of conservation of mass.
		CJa-Vc-2	A chemical reaction is only re-arrangement of atoms, the number of atoms is constant. According to this principle, the chemical reaction equation is balanced.
		CJa-Vc-3	Concepts of mole and simple stoichiometric quantity.
	Changes in aqueous solution (Jb)	CJb-Vc-1	Types and properties of the solutions.
		CJb-Vc-2	Quantification indicates that the temperature of water affects the extent to which a substance dissolves in it.
		CJb-Vc-3	The representation of the volumetric molar concentration.
	Oxidation and reduction reactions (Jc)	CJc-Vc-1	The broad definition of redox is that the loss of electrons is called an oxidation reaction; the gain of electrons is called a reduction reaction.
		CJc-Vc-2	Definitions of oxidizing agents and oxidants, reducing agents and reductants.
	Acid-base reactions (Jd)	CJd-Vc-1	Water can be self-dissociated to produce H^+ and OH^-.
		CJd-Vc-2	According to the acid-base theory of Arrhenius, when a substance is dissolved in water and the H^+ ion is dissociated, it is an acid; if the OH^- ion is dissociated, it is a base.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
		CJd-Vc-3	$pH=-\log[H^+]$,This value represents the degree of acidity and alkalinity of an aqueous solution.
		CJd-Vc-4	An acid or a base that is almost 100% dissociated in an aqueous solution is a strong acid or a strong base; otherwise, it is a weak acid or a weak base.
	Chemical reaction rate and equilibrium (Je)	CJe-Vc-1	At a constant temperature, the solubility of the solute of the saturated solution is constant, because the solute dissolves and crystallizes in dynamic equilibrium.
		CJe-Vc-2	The effect of the contact area of the substance on the reaction rate.
	Properties, preparations, and reactions of organic compounds (Jf)	CJf-Vc-1	Properties and functions of carbohydrates, proteins, oils, and nucleic acids.
		CJf-Vc-2	Common surfactants include soaps and detergents, which consist of a combination of lipophilic and hydrophilic ingredients.
		CJf-Vc-3	Properties and application of surfactants.
Science, technology, society, and humanities (M)	Relationship between science, technology and society (Ma)	CMa-Vc-1	Chemical manufacturing processes can impact daily life, society, the economy, the environment, and ecology.
	History of science development (Mb)	CMb-Vc-1	The contribution of different genders, backgrounds, and ethnic groups in the modern chemical science development process.
		CMb-Vc-2	The development of future science.
	Applications of science in daily life (Mc)	CMc-Vc-1	The process of water treatment.
		CMc-Vc-2	Common medicines in daily life.
		CMc-Vc-3	The application of chemistry in the development of advanced technology.
	Environmental pollution and prevention (Me)	CMe-Vc-1	Acid rain related information, including causes, influences and methods of prevention.
		CMe-Vc-2	Global-warming related information, including causes, influences, and solutions.
		CMe-Vc-3	Ozone hole related information, including causes, influence and methods of prevention.
		CMe-Vc-4	The impact and reuse of industrial wastewater.
Resources and sustainable development (N)	Sustainable development and utilization of resources (Na)	CNa-Vc-1	Sustainable development should satisfy the needs of contemporary society without jeopardizing development for the next generation.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
		CNa-Vc-2	Apply the concept of sustainability to real life.
		CNa-Vc-3	Water resource recycling and reuse.
		CNa-Vc-4	Water cycle and carbon cycle.
	Development and utilization of energy (Nc)	CNc-Vc-1	The current energy situation in Taiwan, for example, emerging energy sources and alternative energy sources.

D. Earth sciences

Items	Sub-Items	Stage V (MOE-mandated required courses)	
Physical systems (E)	The universe and celestial bodies (Ed)	EEd-Vc-1	Our Universe which is made up of celestial bodies with various scales is expanding.
		EEd-Vc-2	The brightness and luminosity of celestial bodies are represented by apparent magnitude and absolute magnitude.
		EEd-Vc-3	Astronomical observations can be performed using different frequency groups of electromagnetic waves.
		EEd-Vc-4	The color of a star can be used to determine its surface temperature.
Earth environment (F)	The materials of the Earth (Fa)	EFa-Vc-1	Seismic waves can help us understand that the Earth is composed of several solid layers with different properties.
		EFa-Vc-2	The chemical composition and physical state of each layer of the Earth is different.
		EFa-Vc-3	The temperature and pressure of the atmosphere change with different height.
		EFa-Vc-4	The salinity of ocean surface water is mainly affected by factors such as precipitation, evaporation, and river injection.
		EFa-Vc-5	The temperature of ocean water varies with depth and horizontal distribution.
	Earth and space (Fb)	EFb-Vc-1	The apparent motion of stars as observed from the Earth can be divided into diurnal motion and annual motion.
History of the Earth (H)	Origin and evolution of Earth (Ha)	EHa-Vc-1	Astronomers use the solar nebula theory to explain the origin and formation of the Solar system. The Solar system is composed of celestial bodies such as the Sun, planets, satellites, asteroids, and comets.
		EHa-Vc-2	Compared with other terrestrial planets and small objects in the Solar system, the environment of the Earth is unique, and it is extremely suitable for the birth and

Items	Sub-Items	Stage V (MOE-mandated required courses)	
			reproduction of life.
		EHa-Vc-3	Oceans and organisms play extremely important roles s in the evolutionary process of the Earth's atmosphere.
	Strata and fossils (Hb)	EHb-Vc-1	Fossils can be used as tools to aid in determining the relative geologic age of the strata.
		EHb-Vc-2	Fossils and Radiocarbon dating in the strata can help us infer the absolute geological age of the strata.
Dynamic Earth (I)	Changes in the Earth's surface and crust (Ia)	EIa-Vc-1	To explain the changing of the Earth’s surface, scientists have proposed major theories such as continental drift, seafloor spreading, and plate tectonics.
		EIa-Vc-2	Plate boundaries can be divided into three types: convergent, divergent, and transform faults.
		EIa-Vc-3	There are various geological and magma activities at plate boundaries.
		EIa-Vc-4	From the characteristics of geological structure and hypocenter distribution, it can be inferred that Taiwan is located at a convergent plate boundary.
	Weather and climate change (Ib)	EIb-Vc-1	Under a fixed pressure, the higher the temperature is, the more water vapor the air contains.
		EIb-Vc-2	When the air is saturated with water vapor, the excess water vapor will be condensed or deposited.
		EIb-Vc-3	The amount of water vapor in the air can be expressed as humidity.
		EIb-Vc-4	When the air rises, it cool down due to expansion.
		EIb-Vc-5	The horizontal movement of the atmosphere is mainly affected by the pressure gradient force, the Coriolis force, and the frictional force.
		EIb-Vc-6	Weather charts drawn from the data of meteorological observations at various locations are used to analyze the weather.
		EIb-Vc-7	The interaction between atmosphere and ocean affects the weather and generates climate variations such as El Niño-Southern Oscillation.
	Movement of the sea (Ic)	EIc-Vc-1	The surface ocean currents are affected by prevailing winds.
		EIc-Vc-2	The formation of sea waves is caused by the wind blowing on the sea. Coastal terrain is affected by sea waves.
		EIc-Vc-3	Tidal changes are periodic due to the influence of the Sun-Earth-Moon system.

Items	Sub-Items	Stage V (MOE-mandated required courses)	
		EIc-Vc-4	In the Taiwan Strait, the movements of tidal currents are different depending upon the location.
	Day, night and season (Id)	EId-Vc-1	The position of the sun in the sky changes throughout the day, and the path of the sun through the sky changes with the different seasons.
Science, technology, society, and humanities (M)	Natural disasters and prevention (Md)	EMd-Vc-1	There are necessary conditions and mechanisms for the generation of a typhoon.
		EMd-Vc-2	The structure of a typhoon consists of spiral cloud bands with the lowest pressure in the center.
		EMd-Vc-3	The paths of typhoons invading Taiwan are mainly guided by the Pacific High Pressure factor. Different typhoon paths produce various degrees of influence in the wind and rain across Taiwan.
		EMd-Vc-4	Taiwan is located at an active tectonic plate boundary. Earthquakes caused by fault activities often result in disasters that cause huge damages and losses.
Resources and sustainable development (N)	Sustainable development and utilization of resources (Na)	ENa-Vc-1	Sustainable development is important for the continuance of the Earth and humanity.
		ENa-Vc-2	Reasonable development and using resources efficiently can reduce the impact of human beings on the global environment as well as contribute to sustainable development.
		ENa-Vc-3	Understanding the global environment can help us achieve sustainable developments in the economy, ecology, culture, and policy.
	Climate change impact and adaptation (Nb)	ENb-Vc-1	Climate change has a characteristic of multiple time scales
		ENb-Vc-2	The organisms and the natural environments on the Earth can be affected by the changes in temperature and the rise/fall of sea level in the glacial and interglacial periods.
		ENb-Vc-3	The rapid climate change in recent decades cannot be fully explained by the principles that used to dominate the long-term natural climate change of the Earth. Based on current scientific evidence, human activities are the major cause of climate change.
		ENb-Vc-4	Climate change adaptation has many aspects and methods.

E. The contents of "Inquiry and Practices" course in Natural Sciences

The Natural Science "Inquiry and Practices" course for upper secondary school is a new compulsory course. The

course makes up a third of the MOE-mandated curriculum in natural sciences, which can be implemented in two semesters. The purpose of the aforementioned course is, through hands-on practice, to cultivate the students' abilities to discover, understand, and solve problems, as well as their capacities to conclude, express and communicate, toward the world of matter and life.

The course includes inquiry-oriented practice, cross-subject learning materials, and multifaceted teaching and assessment approaches, directed to nurture students' core competencies of spontaneity, communication, interaction, and practical participation. Furthermore, the course offers students a learning environment and opportunities to experience scientific inquiry and problem solving; the course helps students to develop a positive attitude towards science and to increase learning motivation; the course cultivates students' ability to think scientifically and to discover key problems; the course guides students to explore the development of scientific knowledge and the characteristics of scientific community, in order to understand the nature of science. This course is a continuation of the inquiry and practice courses at the elementary school and junior high school levels, focusing on the cultivation of citizens' scientific literacy. Therefore, the inquiry and practice course is listed as a compulsory lesson.

The inquiry and practice course of natural sciences is designed to provide students a coherent learning experience. The course emphasizes cross-subject integration, liberally applying the seven cross-subject concepts (matter and energy, structure and function, system and scale, change and stability, interaction, science and daily life, and resource sustainability), in the hope of building a reciprocal relationship between theory and practice. Students should systematically learn knowledge, interdisciplinary dialogue and critical thinking while concentrating on practical and daily-life oriented topics and issues. Therefore, the inquiry and practice course of natural sciences does not distinguish among subjects basically. Through proper questioning of topic inquiry and hands-on activity, the course guides students to experience scientific practices and gradually constructs a higher-level of independent thinking as well as teamwork skills. Future citizens with scientific literacy who can actively and rationally participate in public decision making, therefore, are born, which achieves the educational objective of "nurture by nature."

The learning focus of inquiry and practices course of natural sciences comprises two parts: "Inquiry-based learning content" and "Practice-based learning content." The "Inquiry-based learning content" part concentrates on scientific inquiry and is divided into four major topics: Finding Questions, Planning and Researching, Argumentation and Construction of Models, Communicating and Sharing. Please find the detail of these topics in the following table. The "Practice-Based Learning Content" part offers operative scientific activities, such as observation, measurement, data collection and analysis, deduction and explanation; argumentation and conclusion. There is no predetermined order for each topic of the inquiry-based and practice-based learning content, as this course can proceed in a loop or as a recursion following the subject or practice activity.

Inquiry-Based Learning Content		Practice-Based Learning Content
◎ **Finding questions** Based on curiosity, knowledge-seeking, or needs, students observe the phenomena of their surroundings and the external world, to discover questions suitable for inquiry. Following that, students collect and organize the information needed and formulate solvable or testable research questions. Subsequently, they predict possible outcomes and offer ideas, hypotheses, or models.	Observe phenomena	• To observe the daily experiences, learning activities, natural environment, prints, or online media. • To utilize senses or equipment to distinguish the traits of objects and phenomena. • To observe the changes in objects and things in different time or space. • To induce possible causes behind the observed phenomena.
	Collect information	• To judge the credibility of the source of information, by using data collected from newspapers, books, the Internet, and media. • To read and comprehend the information content. • To organize and extract appropriate information.
	Formulate or identify questions	• To develop upon observation, students ask questions suitable for scientific inquiry through collecting information, reading, and discussion. • To distinguish and prioritize important questions among different issues.
	Provide confirmable opinions	• To provide ideas, hypotheses, or models according to the selected questions.
◎ **Planning and researching** Based on the questions asked, students design a research project and schedule. By identifying which variables may affect the outcome, students choose or design proper tools or equipment to conduct observation. It helps students to obtain useful data or examine the optimized conditions concerning the expected goals and test results.	Search variables or conditions	• To judge the factors that impact the concerned research questions and to analyze the relation of those factors. • To reasonably predict possible outcomes of an inquiry.
	Design research project	• To plan appropriate approaches, materials, equipment, and procedure based on the asked questions. • To employ or assemble proper tools and equipment.
	Collect data	• To accurately and safely operate tools and equipment. • To design a proper record format and to document the project in detail. • To systematically collect qualitative or quantitative data or to examine the optimized conditions.
◎ **Argumentation and construction of models** By analyzing data, students suggest scientific claims or conclusions, discover new knowledge, or identify solutions. They also build models to present or predict the relationship between different variables. By comparing and contrasting their data with other research outcomes, students promote the credibility	Analyzing data and presenting evidence	• To organize data effectively by using approaches such as information and mathematics. • To draw figures and tables from the organized data. • To organize rules and offer analyzed results and connected evidence, following the data collected from the inquiry. • To examine credibility and accuracy by comparing one's findings with classmates and other related information or evidence.
	Explanation and reasoning	• To identify the implications behind the changes and trends of data. • To speculate possible causal relations from the relationships among data. • To explain the inquiry outcome.
	Propose conclusions or solutions	• To construct arguments from the explanations by inquiry. • To suggest a reasonable solution derived from the evidence. • To draw conclusions, new concepts, or questions from the inquiry result. • To compare and contrast the student's own conclusions with classmates' conclusions and other related information or evidence.

Inquiry-Based Learning Content		Practice-Based Learning Content
of their research and acknowledge the limitation of inquiry.	Construction of models	• To try and build a reasonable model based on the inquiry outcome to describe the observed phenomena. • To perceive the limitation(s) of a model.
◎ **Communicating and sharing** Using proper communication tools, students present significant findings, share new scientific knowledge and ideas with others, and promote individual or group research outcomes.	Express and communicate	• To correctly use ways of expression like oral and written language, pictures, videos, or objects. Students present their own, or grasp other people's inquiry process and outcomes. • To correctly use scientific terms, symbols, or models. To present their own, or grasp other people's inquiry process and outcomes. • To describe the inquiry outcome in a structured and scientific manner. • To use various resources to share scientific information with others.
	Collaboration and discussion	• To listen to others' reports carefully and provide concrete opinions or suggestions. • To evaluate classmates' inquiry processes, outcomes, or evaluate the advantages and limitations of a model, while offering reasonable doubts or ways of improvement.
	Evaluation and reflection	• To reflect on the applicability, limitation, and ways of improvement regarding an inquiry outcome. • To assess and judge different scientific information, and to examine for authenticity and credibility. • To experience scientific inquiry that emphasizes empirical evidence from practices, logical induction, and the replicability of inquiry outcome. • To acknowledge that scientific knowledge is one of the viable explanations people used to understand a phenomenon, but not the only explanation.

4. Enrichment and Expanded Elective Courses in Upper Secondary School

(1) Learning performance

Items	Sub-Items	Stage V (enriched elective subjects)	
Inquiry ability – Thinking ability (t)	Imagination and creativity (i)	ti-V a-1	Students can be mindful of the cause of natural science questions independently. And, they can propose hypotheses and viable solutions, in accordance with different scenarios. Furthermore, they can design various types of experiment steps or create new experimental methods by themselves or as a group.
	Reasoning and argumentation (r)	tr-V a-1	Students can employ a series of scientific evidence or theory and deduction approaches, such as analogy and transformation, to comprehend and infer the causal relation of natural phenomena, or to revise and explain arguments.
	Critical thinking (c)	tc-V a-1	Students can compare the rationale of a scientific fact through different arguments, evidence, or factual explanations. Furthermore, they can judge arguments critically or the correctness of scientific evidence through the process of exploring the evidence, provocative thoughts, and responding to diverse opinions.
	Construction of models	tm-V a-1	Students can build models from scientific questions

Items	Sub-Items	Stage V (enriched elective subjects)	
	(m)		by themselves or through collective discussion. Furthermore, they can use analogy or abstraction to describe a systematic scientific phenomenon. They can analyze the characteristics of various models and acknowledge that the models can be modified in response to a deeper understanding of the complexity of scientific facts.
Inquiry ability - Problem-solving (p)	Observing and identifying (o)	po-V a-1	Students can conduct planned, systematic, efficient observation and become further be aware of problems from learning activities, daily experience, technology application, the natural environment, books, and online media, etc.
		po-V a-2	Students can postulate critical questions (or hypotheses) connected with daily life or academic research based on observation, data collection, reading, thinking, and discussion. Moreover, they can distinguish and prioritize essential questions (or hypotheses) between several problems.
	Planning and executing (e)	pe-V a-1	Students can differentiate several independent or dependent variables, plan the right amount of tests, and carefully predict the possible outcomes of the activity and reasons for potential failures. Under limited guidance and based upon instructions or creativity, students can efficiently plan an optimized practice (or deduction) inquiry activity or problem-solving activity, in accordance with aspects such as the characteristics of questions, learning resources (equipment, time, manpower, etc.), expected outcome (including reliability and validity), and impacts on the social environment.
		pe-V a-2	Students can accurately and safely operate objects, tools, technological equipment, and resources corresponding to their learning stage. They can conduct precise, highly efficient qualitative observation or quantitative measurement, using technological tools to assist documentation if needed.
	Analyzing and finding (a)	pa-V a-1	Students can employ various sophisticated approaches such as thinking skills, chart drawing, information using, and mathematics, to effectively organize information or data.
		pa-V a-2	Students can apply methods such as scientific principles, intelligent thinking skills, mathematics, and statistics to construct an explanation, discover unknown knowledge, apprehend causality, understand scientific questions, solve problems, or find fresh inquiries, from learned information or data. Moreover, students can compare and cross-examine their findings with classmates, or with other relevant information, to scrutinize the results. If the results are different, they can explore the reason of the difference further.
	Discussing and communicating (c)	pc-V a-1	Students can understand classmates' inquiry processes and results (or simplified scientific reports), and provide reasonable and relatively complete questions or opinions. Moreover, they

Items	Sub-Items	Stage V (enriched elective subjects)	
			can reflect, and develop evaluations and improvement plans of the whole inquiry process, and include observation and question defining, deduction and practice, the reliability and validity of data, resource application, activity safety, inquiry results, etc., to set the foundation for future improvement and skill enhancement.
		pc-Va-2	Students can utilize oral and written language, images (e.g., photography, filming), pictures, drawings, objects, scientific terminology, mathematical algorithms, models, etc., to present inquiry process, findings, or achievements. Additionally, they can choose the proper ways of expression. They can summarize the goals, characteristics, approaches, findings, values, limitations, applications, and prospects, if needed.
Attitude towards science and the nature of science (a)	Cultivate interest in scientific inquiry (i)	ai-Va-1	Students can understand that having enthusiasm is an essential condition for engaging in science or technology-related work. They also should know that scientific competences are diverse.
		ai-Va-2	Students can appreciate the aesthetics of science by understanding the parsimony of scientific theories, the rigor of scientific thinking, and the order in complex natural phenomena.
	Develop the habit of applying scientific thinking and inquiry (h)	ah-Va-1	Students can understand that scientists often follow specific standards (e.g., generalization, parsimony, etc.) to judge the feasibility of inquiry activities.
		ah-Va-2	Students can use scientific thinking models, such as logical thinking, precision, and objectivity, to judge the credibility of scientific information in daily life.
	Understanding the nature of science (n)	an-Va-1	Students can understand that scientific practitioners have some common qualities, such as thinking logically and being, accuracy, being open-minded, objectivity, and being skeptical. They also emphasize the reproducibility of research results, as well as honesty and ethics in sharing to the public all research results.
		an-Va-2	Students can perceive that the same natural phenomena can be explained by multiple theories. They also need to understand that if those theories are supported by existing evidence identically, people tend to adopt parsimonious ones.
		an-Va-3	Students can understand that the history of the development of scientific knowledge is closely related to society, culture, politics, and the economy.

(2) Learning Content

A. Biology

Items	Sub-Items	Stage V (enriched elective subjects)	
Structure and function of	Structure and function of cells	BDa-Va-1	The molecular composition of cells.
		BDa-Va-2	The structure and function of biomembrane.

Items	Sub-Items	Stage V (enriched elective subjects)	
organisms (D)	(Da)	BDa-V a-3	The function of enzymes and the factors that influence enzyme activity.
		BDa-V a-4	Respiration includes aerobic respiration, anaerobic respiration, and fermentation.
		BDa-V a-5	Energy flow in living systems.
		BDa-V a-6	The life cycle of a cell.
	Structure and function of plants and animals (Db)	BDb-V a-1	The structure and function of animal tissues.
		BDb-V a-2	The structure and function of the organ systems in animals.
		BDb-V a-3	The physiological significance and importance of the homeostasis of animals.
		BDb-V a-4	Animals' reactions to stimuli.
		BDb-V a-5	The regulation of the physiological effects of the nervous system in animals.
		BDb-V a-6	The regulation of the physiological effects of hormones in animals.
		BDb-V a-7	The defensive structure and function of animals.
		BDb-V a-8	The reproduction and embryogenesis in animals.
		BDb-V a-9	The compositional level of plants.
		BDb-V a-10	Photosynthesis includes photoreaction and carbon fixation.
		BDb-V a-11	The reproduction of plants.
		BDb-V a-12	The transportation of materials in plants.
		BDb-V a-13	Plant hormones can regulate the physiological actions of plants.
		BDb-V a-14	The reactions of plants to environmental stimuli.
Earth environment (F)	Composition of the biosphere (Fc)	BFc-V a-1	The research level of ecology is mainly divided into individuals, populations, communities, ecosystems, and the biosphere.
		BFc-V a-2	The main ecosystems in Taiwan can be divided into natural and artificial ecosystems.
Evolution and heredity (G)	Reproduction and inheritance (Ga)	BGa-V a-1	Development of the chromosome theory of inheritance.
		BGa-V a-2	The process of confirming DNA as genetic material.
		BGa-V a-3	The replication of genetic information.
		BGa-V a-4	Transcription and translation of genetic information.
		BGa-V a-5	The regulation of gene expression.
		BGa-V a-6	Genetic variation.
		BGa-V a-7	The application of biotechnology.
	Evolution (Gb)	BGb-V a-1	Debates between biogenesis and abiogenesis.
		BGb-V a-2	Exploring the process of the origins of life based on the evolution of inorganic matter to organic matter.
		BGb-V a-3	The evolution and formation of Prokaryotic cells.
		BGb-V a-4	The evolution and formation of eukaryotic cells.
		BGb-V a-5	Modern evolution theory.
		BGb-V a-6	Population genetics.
		BGb-V a-7	Evolution and speciation.

Items	Sub-Items	Stage V (enriched elective subjects)	
	Biodiversity (Gc)	BGc-V a-1	Biodiversity includes three dimensions: genetic diversity, species diversity, and ecosystem diversity.
		BGc-V a-2	Genetic diversity.
		BGc-V a-3	Species diversity.
		BGc-V a-4	Ecosystem diversity.
		BGc-V a-5	The factors that contribute to Taiwan's biodiversity.
		BGc-V a-6	Biodiversity and conservation.
Organisms and the environment (L)	Interaction between organisms and the environment (Lb)	BLb-V a-1	The levels of ecological research.
		BLb-V a-2	The characteristics of the population include population size, population density, population growth curve, survival curve, and age structure.
		BLb-V a-3	The interactions, structures, and successions between populations in a community.
		BLb-V a-4	Abiotic and biotic factors, energy flow, and element cycle in an ecosystem.
Science, technology, society, and humanities (M)	Relationship between science, technology and society (Ma)	BMa-V a-1	The ethical and legal issues of surrogate mothers.
		BMa-V a-2	The Human Genome Project: its significance and importance.
	History of science development (Mb)	BMb-V a-1	Exploring the development of the biomembrane model from the perspective of the history of science.
		BMb-V a-2	Exploring the relevant experiments in the discovery of auxin from the perspective of the history of science.
		BMb-V a-3	Describing the development of the chromosome theory of inheritance from the perspective of the history of science.
		BMb-V a-4	Exploring the relevant experiments and inferences for genetic linkage from the perspective of the history of science.
		BMb-V a-5	Exploring the confirmation of DNA as genetic material from the perspective of the history of science.
		BMb-V a-6	Exploring the development of DNA molecular structure models from the perspective of the history of science.
		BMb-V a-7	Exploring the development of the idea that “DNA replication is a semi-conservative replication model” from the perspective of the history of science.
		BMb-V a-8	Describing the development of modern biological evolution theory from the perspective of the history of science.
	Application of science in daily life (Mc)	BMc-V a-1	The application of biotechnology.
		BMc-V a-2	Conservation strategies based on ecological theories.
		BMc-V a-3	Exploring biodiversity conservation using practical cases from research, education, legislation, or administration.
Resources and sustainable	Sustainable development and	BNa-V a-1	The impact of marginal effects caused by the fragmentation of habitats on species diversity.

Items	Sub-Items	Stage V (enriched elective subjects)
development (N)	utilization of resources (Na)	BNa- V a-2 The impact of invasive species on species diversity.

B. Physics

Items	Sub-Items	Stage V (enriched elective subjects)	
Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba)	PBa-Va-1	Work is defined as a product of force and displacement. Power is defined as the work that is done per unit of time.
		PBa-Va-2	Work-kinetic energy theorem.
		PBa-Va-3	The definition of potential energy.
		PBa-Va-4	The general expressions of for gravitational potential energy and elastic potential energy.
		PBa-Va-5	The principle of the conservation of mechanical energy and examples.
	Temperature and heat（Bb）	PBb-Va-1	The equation of the Ideal Gas Law is PV = nRT, with T being the absolute temperature.
		PBb-Va-2	Using Newton's 2nd law of motion and the Ideal Gas Law to derive the quantitative relation between pressure, volume and internal energy of an ideal gas, it can be shown that the internal energy of an ideal gas is directly proportional to its absolute temperature.
		PBb-Va-3	The gas molecules in a system do not move with the same speed but have a speed distribution.
Physical systems (E)	Scales and units of nature（Ea）	PEa-Va-1	All measurements have a degree of uncertainty: caused by the objects to be measured, the environment, the limitation of the measuring instrument and the skill of the experimenters making the measurements. There is international agreement on the method of calculating the uncertainty.
	Force and movement (Eb)	PEb-Va-1	When a particle moves in a plane, its displacement, velocity, and acceleration have two independent components.
		PEb-Va-2	The mathematical relationship between displacement, velocity, acceleration, and time in linear uniform accelerated motion, such as free fall.
		PEb-Va-3	When two particles move on the same line, the relative velocity is the velocity difference between the two particles.
		PEb-Va-4	The simple harmonic motion is a periodic motion whose displacement and velocity can be expressed by a sine function or a cosine function of time.
		PEb-Va-5	When a particle moves on a plane, its displacement, velocity, and acceleration have two components, and should be represented by a vector. For example, the trajectory of a projectile's motion is a parabola.

Items	Sub-Items	Stage V (enriched elective subjects)	
		PEb-V a-6	The speed and angular velocity of a particle in uniform circular motion are constant. The direction of its velocity varies with time due to centripetal acceleration.
		PEb-V a-7	A force is a vector that can be composed and decomposed.
		PEb-V a-8	Newton's three laws of motion: The law of inertia, the law of force and acceleration, the law of action and reaction.
		PEb-V a-9	The application of Newton's second law of motion, such as simple harmonic motion and uniform circular motion.
		PEb-V a-10	The momentum of a particle is the product of the mass of the particle and its velocity. The time rate of change of momentum is equal to the force acting on the particle. The change of momentum is impulse.
		PEb-V a-11	The time rate of change of momentum of a particle system is equal to the sum of the external forces. The momentum of a system is constant if the sum of the external forces acting on the system is zero.
		PEb-V a-12	The definition of the center of mass of a particle system.
		PEb-V a-13	The relationship between the velocity of the center of mass, the acceleration of the center of mass, and total system momentum, and the external forces
		PEb-V a-14	The angular momentum of a particle is the cross product of the particle's position, its vector and its momentum. The time rate of change of angular momentum is equal to the torque exerted on the particle.
		PEb-V a-15	Many problems in daily life and engineering such as static equilibrium, friction, and one-dimensional collision problems can be explained or calculated using Newton's three laws of motion.
Phenomena and interactions in nature (K)	Waves, light, and sound (Ka)	PKa-V a-1	Mechanical waves need to propagate in media, but light can propagate in vacuum.
		PKa-V a-2	Waves form when media vibrate.
		PKa-V a-3	Sine waves are periodic in time and in space.
		PKa-V a-4	Waves such as string waves reflect and transmit when they encounter a different media.
		PKa-V a-5	Superposition of waveforms can be applied if linear waves overlap.
		PKa-V a-6	Two waves of the same amplitude, wavelength, and period traveling toward each other form a standing wave by means of interference.

Items	Sub-Items	Stage V (enriched elective subjects)	
		PKa-Va-7	If sound waves form standing waves the one with the lowest frequency is known as the fundamental tone, and those with higher frequencies are called overtones.
		PKa-Va-8	When the frequency of the object of vibration and the frequency of the sound wave are the same, a resonance situation is created.
		PKa-Va-9	Huygen's Principle explains wave propagation, and each point of the wave front is like a point source that propagates outward.
		PKa-Va-10	Light has properties of waves.
		PKa-Va-11	According to Snell's law, total internal reflection occurs when the angle of incidence of light entering a medium of lower refractive index from a medium of higher refractive index is greater than the critical angle.
		PKa-Va-12	Images formed by a lens can be analyzed by the equation of lens.
		PKa-Va-13	In the interference and diffraction phenomena of light, the bright and dark lines are determined by the phase differences.
	Universal gravitation（Kb）	PKb-Va-1	A description of the law of universal gravitation.
		PKb-Va-2	Gravity and gravitational acceleration near the Earth’s surface.
		PKb-Va-3	The motion of planets and satellites.
		PKb-Va-4	Using uniform circular motion as an example to demonstrate how to derive Kepler's law from the law of universal gravitation.
	Electromagnetic phenomena（Kc）	PKc-Va-1	The magnitude and direction of electrical fields can be represented by electrical field lines.
		PKc-Va-2	Coulomb force is a conservative force with potential energy.
		PKc-Va-3	The potential energy of a unit charge at a certain point in an electrical field is the electric potential at that point.
		PKc-Va-4	Ohm's law stated the voltage difference is equal to the current times the resistance.
		PKc-Va-5	The electric current in circuits carries energy.
		PKc-Va-6	The circuit has serial, parallel and loop patterns. The energy and electric charge in the circuit must be conserved.
		PKc-Va-7	Current-carrying conducting wires, such as long straight wires, circular coils, and long solenoids, generate magnetic fields that must follow the Biot–Savart law and Ampère’s right-hand rule.
		PKc-Va-8	A current-carrying conducting wire experiences a

Items	Sub-Items	Stage V (enriched elective subjects)	
			force when placed in a magnetic field. This property can be used to design electric motors.
		PKc-Va-9	A particle moving on a plane perpendicular to a uniform magnetic field will experience force and be in uniform circular motion.
		PKc-Va-10	Faraday's Law states that the electromotive force around a closed path is equal to the negative of the time rate of change of magnetic flux enclosed by the path.
		PKc-Va-11	Voltage and current have two types: direct current (DC) and alternating current (AC).
		PKc-Va-12	Electromagnetic Induction is the basic principle for operation of transformers and generators.
		PKc-Va-13	A changing electric field produces a magnetic field.
		PKc-Va-14	The propagation speed of electromagnetic waves in a vacuum is determined by the electric permittivity and magnetic permeability and is independent of the frequency
		PKc-Va-15	The electric field, magnetic field and direction of propagation of a plane electromagnetic wave are perpendicular to each other.
	Quantum phenomena（Kd）	PKd-Va-1	Measure the charge-to-mass ratio and charge of an electron with Thomson’s cathode-ray tubes and Millikan’s "oil drop" experiment.
		PKd-Va-2	X-rays have shorter wavelength and higher energy compared to visible light, and can be used to analyze crystal structures. There are many other applications.
		PKd-Va-3	Planck studied the phenomena of blackbody radiation and proposed a quantum interpretation.
		PKd-Va-4	Einstein analyzed the photoelectric effect and proposed the theory of light quanta.
		PKd-Va-5	De Broglie proposed the theory of matter wave (later verified by experiments): wave-particle duality for all matter.
		PKd-Va-6	In Rutherford's model the atom has a positively charged core surrounded by electrons.
		PKd-Va-7	Bohr made the assumption of the quantization of angular momentum and proposed the Bohr model to interpret successfully the hydrogen energy spectrum.
		PKd-Va-8	According to quantum mechanics, electrons in an atom have a probability of distribution instead of fixed orbits.
	Basic interactions (Ke)	PKe-Va-1	Protons and Neutrons can form structurally stable or unstable nuclei.
		PKe-Va-2	Unstable nuclei will release energy or transform into other nuclei by means of radioactive decay.

Items	Sub-Items	Stage V (enriched elective subjects)	
		PKe-Va-3	The fundamental interaction follows many conservation laws, such as conservation of momentum, conservation of angular momentum, mass-energy conservation, and charge conservation.
Science, technology, society, and humanities（M）	History of science development (Mb)	PMb-Va-1	The relationship between Kepler's laws and the law of universal gravitation.
		PMb-Va-2	The relationship between the principle of inertia and Newton's law of motion.
	Application of science in daily life（Mc）	PMc-Va-1	Interpretation of natural phenomena through physical principles, such as various phenomena of light, celestial motion, and the effects of various forces.
		PMc-Va-2	Applications of circuits, electromagnetic waves, lenses, nuclear energy, and photoelectric effects.

C. Chemistry

Items	Sub-Items	Stage V (enriched elective subjects)	
Composition and characteristics of matter (A)	Composition of matter/materials and periodicity of elements (Aa)	CAa-Va-1	The structure of an atom. The nucleus is in the middle and electrons exist at different energy levels.
		CAa-Va-2	The Bohr hydrogen atom model explains the spectrum of the hydrogen atom and the Rydberg formula.
		CAa-Va-3	The electrons of a multi-electron atom and its orbitals can be illustrated by four quantum numbers.
		CAa-Va-4	The rules for the filling of atomic electron configurations include the Pauli Exclusion Principle, Hund's rule, and the Aufbau Principle.
		CAa-Va-5	Electron configurations and properties of elements are closely related. And they can exhibit cyclic variations across the periodic table.
	Form, properties, and classification of matter/materials (Ab)	CAb-Va-1	The nature of chemical bonds affect the property of matter.
		CAb-Va-2	Different functional groups can affect the properties of organic compounds.
		CAb-Va-3	The state and properties of liquid crystals.
		CAb-Va-4	The kinds of classifications in the periodic table.
Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba)	CBa-Va-1	Transformation between chemical energy and other forms of energy.
		CBa-Va-2	Factors affecting combustion reactions include temperature, pressure, and the amount and state of the reactants.
		CBa-Va-3	The sum of the total combustion reaction heat follows Hess's law.

Items	Sub-Items	Stage V (enriched elective subjects)	
		CBa-Va-4	Common combustion reactions including the calculating molar heat of combustion.
Structure and function of matter/materials (C)	Separation and classification of matter/materials (Ca)	CCa-Va-1	Methods and principles for identification of common materials.
	Structure and function of matter/materials (Cb)	CCb-Va-1	The structures and functions of isomers.
		CCb-Va-2	Hybrid orbital theory and valence bond theory: the method and principle of atomic bonding.
		CCb-Va-3	The principles of valence shell electron pair repulsion, mutual exclusion, and molecular shape.
		CCb-Va-4	Molecular shape, structure, polarity and intermolecular forces.
Physical systems (E)	Gas (Ec)	CEc-Va-1	The ideal gas particle model.
		CEc-Va-2	The pressure of a gas.
		CEc-Va-3	The three laws of an ideal gas and the ideal gas equation.
		CEc-Va-4	Dalton's law of partial pressure.
		CEc-Va-5	Students can understand the differences between an ideal gas and a real gas.
Reactions of the materials, equilibrium and production (J)	Law of material reactions (Ja)	CJa-Va-1	Chemical reactions involve inter-atomic recombination and observe mass conservation, atomic immutability, charge conservation and energy conservation.
		CJa-Va-2	The yield of chemical reactions and chemical procedures.
	Changes in aqueous solution (Jb)	CJb-Va-1	The representation of a mole fraction.
		CJb-Va-2	The effect of temperature and pressure on the solubility of a gas.
		CJb-Va-3	Precipitation, separation and confirmation of ions.
		CJb-Va-4	Raoult’s law and ideal solutions.
		CJb-Va-5	Non-volatile substances soluble in water will change various properties of an aqueous solution, for example: the vapor pressure decreases and the boiling point increases; the freezing point decreases and the osmotic pressure increases.
	Oxidation and reduction reactions (Jc)	CJc-Va-1	A half-reaction of common oxidants and reducing agents.
		CJc-Va-2	The rules and applications of oxidation numbers.
		CJc-Va-3	Redox reaction and equilibrium.
		CJc-Va-4	The redox titration principle and quantitative analysis.
		CJc-Va-5	The principle of electrochemical cells.
		CJc-Va-6	The standard reduction potential and the electromotive force of electrochemical cells.
		CJc-Va-7	The principles and design of common batteries.
		CJc-Va-8	The principles of electrolysis and electroplating.

Items	Sub-Items	Stage V (enriched elective subjects)	
	Acid-base reactions (Jd)	CJd-Va-1	Common names of acids and bases.
		CJd-Va-2	Brønsted–Lowry acid-base theory.
		CJd-Va-3	At a constant temperature, the product of [H+] and [OH-] is a constant value called the ion product constant.
		CJd-Va-4	Expression of the ionization constant of a weak acid or a weak base: K_a, acid ionization constant and K_b, base ionization constant.
		CJd-Va-5	The principle and application of the acid-base indicator.
		CJd-Va-6	The principle and quantitative analysis of acid-base titration.
		CJd-Va-7	Types and properties of salts.
		CJd-Va-8	The common ion effect; definition, preparation and functions of buffer solutions.
	Chemical reaction rate and equilibrium (Je)	CJe-Va-1	The reaction rate law.
		CJe-Va-2	Images of reaction energy.
		CJe-Va-3	The collision theory explains the factors that influence the rate of reaction.
		CJe-Va-4	The properties and applications of catalysts and enzymes.
		CJe-Va-5	At a constant temperature, the reaction rate of ions in water equals the bonding rate of atoms; called free ion equilibrium.
		CJe-Va-6	Le Châtelier's principle
		CJe-Va-7	The definition and calculation of equilibrium constants.
		CJe-Va-8	The relationship between solubility equilibrium and solubility product.
	Properties, preparation, and reactions of organic compounds (Jf)	CJf-Va-1	The composition of organic compounds.
		CJf-Va-2	The naming, structure, functional group detection and use of organic compounds, such as: hydrocarbons, halogenated hydrocarbons, alcohols, phenols, ethers, ketones, aldehydes, organic acids, esters, amines and amides.
		CJf-Va-3	Essential reactions of common organic compounds.
		CJf-Va-4	The general properties and classification of common polymers.
		CJf-Va-5	The structure and preparation of common polymers.
Science, technology, society, and humanities (M)	Relationship between science, technology and society (Ma)	CMa-Va-1	The main development direction of chemistry and industrial achievements. Establish the concept of green chemistry and sustainable development. Actively participate in the dissemination of scientific knowledge, and promote the entry of chemical knowledge into personal and social life.
		CMa-Va-2	Chemistry, chemical technology, society, laws, and ethics-related issues.

Items	Sub-Items	Stage V (enriched elective subjects)	
	History of science development (Mb)	CMb-Va-1	Important events in the history of chemistry, related theoretical developments, and research stories of scientists.
		CMb-Va-2	The formation and development of microcosmic chemical concepts.
		CMb-Va-3	The characteristics and evolution of scientific models.
	Applications of science in daily life (Mc)	CMc-Va-1	The properties, preparation, and use of hydrogen.
		CMc-Va-2	The preparation, properties and uses of common metals and essential compounds.
		CMc-Va-3	The properties and use of common alloys.
		CMc-Va-4	The preparation, properties and uses of common non-metals and important compounds.
		CMc-Va-5	The properties and applications of synthetic fibers, synthetic plastics, and synthetic rubbers are common in daily life.
		CMc-Va-6	Advanced materials.
		CMc-Va-7	Nanoscale.
	Environmental pollution and prevention (Me)	CMe-Va-1	Water pollution detection methods.
		CMe-Va-2	Methods for detecting atmospheric pollutants.
Resources and sustainable development (N)	Sustainable development and utilization of resources (Na)	CNa-Va-1	The application of sustainable development concepts.
		CNa-Va-2	The practical methods of resource conservation.
		CNa-Va-3	The concepts of innovative reuse and remanufacturing of waste.
		CNa-Va-4	The nitrogen cycle.
	Development and utilization of energy (Nc)	CNc-Va-1	The possibilities and limitations of emerging and alternative energy sources in Taiwan.

D. Earth sciences

Items	Sub-Items	Stage V (enriched elective subjects)	
Physical systems (E)	The universe and celestial bodies (Ed)	EEd-Va-1	Stellar spectra can be used to understand the physical properties and composition of the atmosphere of stars.
		EEd-Va-2	The main tools for astronomical observation on the ground are optical telescopes and radio telescopes.
		EEd-Va-3	The astronomical observations on the ground are limited by many environmental conditions of the Earth's surface.
		EEd-Va-4	The stars seen from the Earth have different states of time and space. The stars that are farther away from the Earth are older than others.
		EEd-Va-5	The chart for the relationship between the magnitude and color of stars, and helps us understand the type and evolution of stars.

Items	Sub-Items	Stage V (enriched elective subjects)	
		EEd-Va-6	Measurement of the distances between celestial bodies can help us understand the large-scale structure of the universe.
Earth environment (F)	The materials of the Earth (Fa)	EFa-Va-1	The appearance of igneous rock is affected by the composition and cooling rate of magma during its formation.
		EFa-Va-2	The composition of sedimentary rock and the size of its particles is affected by the environment during its depositing.
		EFa-Va-3	The appearance of metamorphic rock is affected by the parent rock and the degree of metamorphism during its formation.
		EFa-Va-4	Minerals have chemical and physical properties.
		EFa-Va-5	There are many kinds of minerals, but only a small group of these minerals are the common rock-forming minerals that are found in most rocks.
		EFa-Va-6	The most common building materials come from rocks and the products of rocks.
		EFa-Va-7	The structure and composition of the solid parts of the Earth can be understood through crustal drilling and various methods of geophysical survey.
	Earth and space (Fb)	EFb-Va-1	After the development of the geocentric model and the heliocentric theory, Heliocentrism, astronomers now understand the law of the revolution of the Earth in space.
		EFb-Va-2	The calendar is primarily formulated from the laws of motion and the apparent motion of celestial bodies.
History of the Earth (H)	Origin and evolution of the Earth (Ha)	EHa-Va-1	With the development of civilization, people's thoughts of the origin and the evolution of the Earth have changed; the approximate content has been clarified in modern times.
		EHa-Va-2	The primitive Earth in a high-temperature molten state underwent differentiation and stratification forming the layered structure of the solid Earth. As it cooled gradually, the atmosphere and oceans evolved on the Earth, during a process of gas release.
		EHa-Va-3	Humans estimate the size and shape of the Earth through various scientific methods.
	Strata and fossils (Hb)	EHb-Va-1	Index fossils, facies fossils, and geological structures can help us understand the depositional environment and depositional age of the strata.
		EHb-Va-2	Different methods of studying the Earth's history have different limitations and levels of precision. Humans need to integrate multi-dimensional evidence to make appropriate inferences about the Earth's history.

Items	Sub-Items	Stage V (enriched elective subjects)	
Dynamic Earth (I)	Changes in the Earth's surface and crust (Ia)	EIa-Va-1	It can be inferred from the principle of buoyancy that there are vertical motions of the Earth's crusts. This inference is supported by observational evidence.
		EIa-Va-2	Faults, folds, and joints are the conformations of the strata forced by the changes in the crust.
		EIa-Va-3	Information obtained through records and analysis of field observations, and geological maps can help us understand the distribution and structure of the local strata.
		EIa-Va-4	Geophysical data obtained by geological observations and instruments can help us establish models of the territorial structure of Taiwan.
		EIa-Va-5	The states of plate motion through monitoring of crustal changes with instruments.
		EIa-Va-6	Remote sensing instruments provide us a more comprehensive view of the motion of the Earth's surface and crust.
		EIa-Va-7	Using various instruments to see the difference in shape and scale of the terrains between the ocean floor and the land.
	Weather and climate change (Ib)	EIb-Va-1	Changes in weather and climate are influenced by the three phases of the water cycle, as well as the transfer of energy between the hydrosphere and the atmosphere.
		EIb-Va-2	Vertical temperature change may make the atmosphere unstable and produce vertical motions.
		EIb-Va-3	The modes of vertical motion in the atmosphere determine the types of clouds and precipitation.
		EIb-Va-4	Weather is affected by the differences between sea and land surface conditions and the different terrains on various scales.
		EIb-Va-5	Weather forecasting is related to daily life. Some industries are in great need of information from weather forecasts.
		EIb-Va-6	Meteorological data can be obtained through ground observations, upper-air observations, and remote-sensing observations from satellite and radar.

Items	Sub-Items	Stage V (enriched elective subjects)	
		EIb-Va-7	Analyzing the records of satellite cloud images and data collected by observations: such as temperature, rainfall, wind direction, wind speed, and relative humidity, can provide appropriate explanations for the changes in weather systems.
	Movement of the sea (Ic)	EIc-Va-1	Thermohaline circulation is the flow of the deep water in the ocean, driven by differences in the density of seawater. It plays an important role in energy transfer and climate regulation.
		EIc-Va-2	The ocean currents around Taiwan affect Taiwan's seasonal climate.
		EIc-Va-3	Can determine the various types of tides through observations.
		EIc-Va-4	Upwelling can transport seawater with nutrients from lower layers to the surface layer, which improves the primary productivity of the sea area.
		EIc-Va-5	Changes in seawater movement and hydrological properties can be understood through exploration and remote sensing of the ocean.
	Day, night and season (Id)	EId-Va-1	The duration of daytime and nighttime at different latitudes varies with the seasons.
		EId-Va-2	Twenty-four solar terms are set according to the position of the Sun as it moves along the celestial sphere.
Science, technology, society, and humanities (M)	Natural disasters and prevention (Md)	EMd-Va-1	There are close relationships between landslides, mudflows, geological environments, and meteorological conditions.
		EMd-Va-2	Soil and water conservation have the function of disaster prevention and mitigation.
		EMd-Va-3	Using techniques such as field surveys, remote sensing, and drilling to identify geologically sensitive areas.
Resources and sustainable development (N)	Sustainable development and utilization of resources (Na)	ENa-Va-1	The distribution of water resources is uneven across the globe, and the supply and use of water resources are limited. It is a major issue facing humanity, especially in Taiwan.
		ENa-Va-2	In addition to saving water, maintaining a natural ecological environment, and conservation of soil and water are positive actions to the sustainable management and utilization of water resources.

Items	Sub-Items	Stage V (enriched elective subjects)	
		ENa-Va-3	Fossil fuels are the most versatile and essential source of energy, but their reserves are limited on the Earth. It will disrupt the balance of the global carbon cycle if we continue using fossil fuels.
		ENa-Va-4	The exploitation of alternative energy gives us the chance to solve contemporary energy problems.
		ENa-Va-5	Face the problem of sustainable development through discussion and balance of the three dimensions: society, the economy, and the environment.
	Climate change impact and adaptation (Nb)	ENb-Va-1	Using various research and climate change models to infer the consequences; taking into account both factors of nature and humanity
		ENb-Va-2	There is significant uncertainty about the inference and the impact of climate change in the future.
		ENb-Va-3	The extents and types of climate change that occur around the world are different.
		ENb-Va-4	The response and adaptation of human beings to the changes in the global environment may prevent disasters.

VI. Implementation Directions

1. Curriculum Development

(1) School curriculum development should be aligned with concepts of taking initiative, engaging in interaction, and seeking the common good indicated in the General Guidelines and foster students' autonomous learning.

(2) To achieve vertical coherence between educational stage, school curriculum development of natural sciences should emphasize integration between subjects and coordinate with the arrangement of domain-specific curriculum guidelines from third to twelfth grade (refer to Table 1: The learning characteristics of students studying natural sciences at different learning stages, Table 2: The framework of learning performances, and Table 3: The framework of learning contents)

(3) Teachers with professional qualifications (i.e. science background, professional certification/workshop, etc.) should be responsible of developing alternative learning hours for interdisciplinary learning of natural sciences in senior high schools. Furthermore, the Committee of School Curriculum Development should review and approve this plan. Students should be provided with various learning resources from the school, community, or off-campus natural environment.

(4) For the natural science inquiry and practice in general senior high schools, schools should develop curriculum plans referring to relevant teaching demonstration and plan periodical short-term or thematic teaching activities for the whole school year. In addition, to support curriculum development, teaching, and assessment, schools should arrange sufficient qualified teachers and increase the number of teachers specializing in natural sciences depending on teacher-pupil ratio. Moreover, schools may assign teachers of different subjects according to the needs of the curriculum. This should comply with the Directions for Development and Implementing of School-Based Curriculum in Senior High School and other regulations.

(5) The curriculum development of natural sciences in elementary schools should integrate appropriate issues, broad ideas, or cross-subject concepts. For the curriculum planning in national junior high schools, schools should implement domain-specific education. In addition, schools should also incorporate subject-specific teaching and encourage

interdisciplinary teaching after the approval of the Committee of School Curriculum Development. The interdisciplinary content accounts for one-sixth of the total teaching hours of the subject and teachers should instruct interdisciplinary themes through experiments, practice, or inquiry. Subject-specific teaching is implemented in general senior high schools:

2. Teaching Material Selection and Composition

(1) Teaching material selection and composition should conform to the learning focus in domain-specific curriculum guidelines and arrange appropriate teaching contents.

(2) When composing textbooks for natural sciences, outline curriculum plans with the learning focus and the development process for the third to the twelfth grade. The goal is to assist teachers in understanding core concepts, inquiry skills, and the development of scientific attitude and the nature of science that articulates across grades based on the curriculum plan.

(3) 3. When composing and selecting teaching materials, schools should be mindful of various images, languages, and texts used. They should be written in languages and texts that promote gender and ethnic equality to avoid specific stereotypes. Furthermore, for conducting culturally responsive teaching, schools with special indigenous focuses are encouraged to select and compose teaching materials that appropriately incorporate local indigenous cultures and tribal life experiences.

(4) There are three guiding principles for implementation of the natural science inquiry and practice in general senior high schools: 1. Curriculum design and development, 2. Problem/issue-oriented inquiry, and 3. Solid references for teaching materials. The selection and composition of teaching materials should be able to assist teachers of different subjects in jointly arranging teaching contents and guide students to conduct inquiry activities according to themes, issues, and interdisciplinary concepts, further developing students' inquiry skills.

(5) To increase students' interest in learning and reduce the difficulty of knowledge comprehension understanding, the selection and composition of teaching materials should incorporate historical facts of scientific discovery and scientists' profiles. Moreover, to help students to develop scientific attitude and inquiry skills through understanding

scientific discovery processes, and thus promoting the understanding of the nature of science, the selection and composition of teaching materials should consider historical facts of local, minority, and women scientists.

(6) The selection and composition of teaching materials should conform to the spirit and content enlisted in the Curriculum Guidelines of 12-Year Basic Education – The Domain of Natural Science. Schools should encourage students to engage in hands-on experience and appropriately arrange practical courses for each grade to achieve the required hours. One-third of the sessions in national junior high schools should be practical courses. To stimulate students' interest in learning and improve learning efficiency, teachers should adequately design activities such as demonstration experiments and outdoor teaching.

(7) The design of practical teaching materials should emphasize operational learning. The practice should strengthen students' process skills through the process of experiment, operation, and inquiry. In addition, it may also cultivate their inductive reasoning, problem identification, problem-solving, and self-learning skills.

(8) Teaching materials for experiments/activities should include detailed descriptions of experimental activities, drug properties, handling methods, and equipment safety.

(9) The translation of technical terms and names in teaching materials should conform to the terminology of the domain/subjects of natural sciences enacted by the Ministry of Education. In cases where it is not specified, reference should be made to current domestic scientific publications and customary terminology. However, the translation must be consistent in each volume and compatible with other related subjects.

3. Teaching Implementation

(1) Instructional design should take into account students' characteristics and physical and mental development and follow the content of core competencies in natural sciences. In addition, it should consider the educational profession and provide resources, opportunities, and environments to guide students to become spontaneous and motivated learners.

(2) Teachers should have l awareness of gender-equality while using teaching materials and engaging in educational activities. They should eliminate gender stereotypes, avoid gender bias and discrimination, and encourage students to pursue non-traditional gender-specific subjects.

(3) Teaching implementation should aims to develop students' problem-solving skills while the planning of learning activities should focus on problem-solving strategies, which include procedures of identifying problems, collecting relevant information, formulating solutions, selecting and implementing solutions, and evaluating and improving solutions.

(4) The principles of teaching implementation include cultivate inquiry skills, cooperative learning, acquiring thinking intelligence, learning operational skills, and achieving curriculum objectives. Therefore, teaching styles should not be confined to one model. Depending on teaching objectives and actual situation, teachers may adopt various methods such as lectures, experiments, practice, project inquiry, field trips or scientific observations, long-term experiments like planting and rearing, etc.

(5) Instructional design, whether for individual or group learning, should foster values of appreciation and tolerance of individual differences, as well as respect for the rights of self and others, in the process of teaching.

(6) Teachers should provide more examples for deductive reasoning of theories or principles when conducting instructional design. This is to stimulate students' motivation to imitate, further examine their reasoning, and learn about experimental procedures and approaches of deductive methods.

(7) When conducting instructional design, teachers should include guiding students to discover problems based on their daily life experiences and existing knowledge or experience. During actual teaching, teachers should flexibly adjust the sequences of textbook units and activities according to regional environment and characteristics.

(8) For instructional designs that need to inductive reasoning for evidence from experiments, teachers should let students carry out experiments so they become proficient in experimental skills and provide them with creative space for self-development. In addition, teachers may assist and guide students by providing them with hands-on experiments to feel the joy of discovery, and let them learn experimental procedures in inductive method and methods by analyzing the results of experimental statistics.

(9) Teachers should incorporate teaching media, experiments/activities, field trips, or outdoor teaching according to the characteristics of teaching materials. Teachers should, in addition to imparting knowledge, focus more on the application of scientific methods, the cultivation of scientific attitudes, and the understanding of the nature of science.

(10) Teachers should refer to curriculum planning and lesson planning before teaching to formulate learning assessment plans to evaluate students' learning outcomes and achieve teaching objectives. Furthermore, teachers should revise lesson planning according to students' learning outcomes to improve the effectiveness and quality of their teaching and attain their professional growth.

(11) Teachers of each school may design the themes of natural science inquiry and practical curriculum according to the learning content of natural science inquiry and practice learning content and school characteristics. Moreover, to enhance cross-subject integration, teachers of different subjects within the domain may provide collaborative teaching.

(12) Teachers should provide supportive and differentiated instruction as well as appropriate counseling measures when teaching students with multicultural backgrounds and special needs, including color vision deficiency, sensory impairments, etc. Moreover, education administration authorities should assist schools in providing appropriate teaching resources.

4. Teaching Resources

(1) Schools should set up laboratories for natural sciences, medicine storerooms, and experimental materials preparation rooms (including emergency eye flush and fire-fighting equipment) according to the "Equipment Standards for Schools at All Levels" promulgated by the Ministry of Education. In addition, schools should also assign full-time laboratory managers according to class size at each educational stage and full-time teachers of each subject should provide assistance after teaching hours. Education administration authorities determine the allocation of relevant management staff and assisting teachers. Moreover, schools should supply adequate equipment, apparatus, and consumables required for laboratory activities. Hence, central and local education administration authorities should appropriately plan and designate budgets to supply experimental materials required by each school and dispose of the toxic waste generated by each school from experimental teaching.

(2) Laboratories used for natural science domain and experiments/activities should consider ventilation, safety and environmental pollution prevention measures. In addition,

teachers should establish rules for proper use and operation of laboratory equipment, replenishment of laboratory supplies, and maintenance of laboratory equipment.

(3) To facilitate teaching activities required in natural sciences, schools could make use of outdoor ecological environments such as ecological ponds, wetlands, ecological parks, etc., in the community or areas accessible by public transportation. For schools that do not meet the above conditions, they may set up mini ecological ponds, wetlands, or ecological parks within permitted area of school's environment.

(4) Schools' relevant personnel should prepare required equipment or apparatus for laboratory classroom and outdoor exploration and survey according to the equipment standards, school curriculum design, teachers' teaching plans, etc., before the start of the school year.

(5) Schools should provide adequate and appropriate relevant facilities, equipment, medicines, and specimens required for teaching according to the content of natural science domain-specific guidelines. Moreover, schools must purchase instructional media including models, wall charts, books, magazines, and CDs necessary for teaching. Lastly, schools also need to provide related equipment and materials that encourage teachers to create their instructional media and make use of digital teaching platform resources.

5. Learning Assessment

(1) The implementation of learning assessment should be based on physical and mental developments of students, conform to the content of core competencies, and follow adopt professional educational assessment. Through the process of multiple assessments, students will acquire the joy of inquiry, develop the working spirit of truth-seeking, cultivate a science-oriented attitude, become spontaneous and motivated learners.

(2) Teachers should first use appropriate methods to assess students' prior knowledge, then, apply appropriate teaching strategies to help students in conducting meaningful and internalized learning based on students' prior knowledge and life experiences.

(3) To understand students' learning status and outcomes, teachers should appropriately conduct formative and summative assessments to assess students' learning outcomes and teaching effectiveness. Teachers may then give remedial instruction and to achieve the desired

teaching objectives. Even with paper-and-pencil tests, teachers should take into account both learning content and performance.

(4) Teacher should conduct self-assessment and assessment of students' learning outcomes, and gradually revise and perfect teaching planning to improve teaching effectiveness.

(5) Learning assessment should adhere to the concept of authentic assessment and be implemented in diverse methods. Teachers should provide assessments as well as guide students to self-evaluate to ensure that they have achieved their learning goals. In addition, teachers can also use this as a reference to improve teaching and enhance teaching effectiveness.

(6) Assessments should provide relevant graphic charts for students' reference according to standards, curriculum objectives, and learning objectives specified in selection and composition of teaching material. To achieve the real purpose of assessment and cultivate students' analytical and reasoning skills, teachers should not ask students to solely recite and memorize.

(7) Assessments should take into account purposes of both summative and formative assessment , and teachers should select different assessment methods according to the assessment purpose and timing. The types of assessment methods include project report, works exhibitions, paper-and-pencil tests, oral reports, experimental design, academic portfolios, etc. Moreover, teachers may instantly keep track of students' learning from the observation of activities such as classroom practice and discussion. The above assessment methods should be used alternately to understand and promote students' learning.

(8) To improve students' reading, speaking, and writing skills for scientific texts, teachers are recommended to use scientific report writing and oral presentation as a summative assessment for high-level competencies. This assessment should be implemented at least once per school year.

(9) Teachers should apply practical assessments in learning activities, especially for natural science inquiry and practical courses. The main purpose is to understand students' learning status and to serve as a reference for improving teaching and learning. Moreover, assessments should be able to stimulate students' self-reflection and thinking, guide students in cherishing self-growth, facing their learning achievements in a balanced attitude, and identify strengths and weaknesses of their learning methods. Finally,

assessments should have the effect of urging and encouraging students to believe that they can achieve better learning outcomes through personal effort or higher level of concentration.