Curriculum Guidelines for the 12-Year Basic Education

Vocational Senior High School

The Domain of Natural Science

Ministry of Education

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I. Fundamental Beliefs

Scientific knowledge is the information from facts and theories that humans obtained in the process of seeking understanding of the universe and nature, as well as from observing and researching various phenomena and changes. Humans use scientific methods to resolve problems, adapt to the environment, and improve life. Scientific knowledge continues to develop and evolve, becoming an integral part of the culture. Thus, based on the beliefs about the curriculum development of the 12-Year Basic Education, the General Guidelines aim to nurture students to become active learners equipped with diverse skills of interacting with nature, and facilitating the attainment of reciprocity and the common good.

The teaching approach for natural sciences in a vocational senior high school should initiate both the learners' curiosity toward science and willingness for active learning. The learners are then guided to start from existing experiences and to explore actively, experiment, and learn in a multifaceted way. The objectives are to obtain the core understanding of scientific knowledge and experiment skills, as well as to develop the communication skills necessary for scientific argumentation. The learning content should integrate contemporary scientific knowledge and other disciplines, and adequately incorporate issues like indigenous groups, energy, safety, disaster prevention, outdoor education, gender equality, human rights, the environment, and the ocean, etc. To develop natural science literacy and lay the foundation of vocational education, students can learn in-depth through approaches such as diverse exploration and experience of experimentation.

Natural sciences education should arouse students’ learning interest in natural sciences in everyday life and turn them into active learners, for achieving the objective of “taking initiative.” The education should encourage students’ diligent scientific attitudes and abilities to resolve daily issues, develop students’ interest and ability of absorbing new scientific knowledge, use different tools to achieve effective communication, for accomplish the objective of “engaging in interaction.” It should also plow the spirit of caring and loving the Earth, grasp the truth of global environmental change, learn to appreciate and cherish the beauty of nature, and devote in sustainable development, for the idea of “seeking the common good.” By integrating the relevant subjects, students can not only obtain the knowledge, affection, and skills of various topics, but they can also develop critical thinking and problem-solving skills from the process of recognizing the backgrounds, traits, phenomena, contents, causes, and impacts of various issues. The education can help to strengthen students’ awareness of their responsibility and actions when facing issues, and support them to pursue core values such as: respect for diversity; compassion

and caring; equality and justice; and sustainable development.

II. Educational Goals and Curriculum Goals

1. The educational objectives of vocational senior high schools are:
   (1) To cultivate core competencies that shapes students into contemporary citizens;
   (2) To strengthen basic knowledge that leads to life-long learning;
   (3) To develop professional skills that matches the industrial needs;
   (4) To develop morality and character that enhances individual values.
2. The curriculum goals of natural sciences

   Guided by the aforementioned fundamental beliefs, the curriculum goals of natural sciences at vocational senior high schools under the 12-Year Basic Education are as follows:

   (1) To inspire students' curiosity and imagination of natural sciences and the potential of active learning, and to cultivate the essential competencies of natural sciences. Equip students the basic intelligence of natural sciences and skills for exploration, so that in daily life students can: communicate effectively; participate in the decision-making and problem-solving of civil society; understand and make judgments regarding science-related contents from media reports.
   (2) To gain basic knowledge of natural sciences; to increase interest in science; to understand scientific methods; to enhance individual learning, systematic thinking, problem-solving, and skills for planning and execution; to inspire creativity and initiative; and so transform students into contemporary citizens who can adapt to life in the age of technology and social change.
   (3) To nurture a world view of social concern, including: appreciation of natural beauty; treasuring limited resources; caring for nature; and devotion to protecting the environment, energy-saving and carbon reduction, which leads to fostering sustainable development and continuous growth of nature.
   (4) To enhance students' expertise in experimental operations and applications of basic sciences, so students can implement it in their future lives or career development. In this way, to help students to prepare for and connect to their next stages of life.

III. Time Allocation

Vocational Senior High School (Stage V)				
Subject	**Version**	**Credits**	**Time Allotment**	**Suggested applicable study areas**
Physics	A	1-2	Depending on the situation of each school, the subject may be taught flexibly for the tenth to twelfth grades.	Business and Administration, Foreign Language Studies, Design, Agricultural Science, Food Science, Home Economics Course Group, Hospitality-Major Category, Fisheries and Aquatic Science, Marine Science, Art
	B	4(+2)	Tenth grade	Mechanics, Power Machinery, Electrical and Electronics Engineering, Chemical Engineering, Civil Engineering and Architecture
Chemistry	A	1	Depending on the situation of each school, the subject may be taught flexibly for the tenth to twelfth grades.	Business and Administration, Foreign Language Studies, Design, Home Economics Course Group, Hospitality-Major Category, Art
	B	2-4	Depending on the situation of each school, the subject may be taught flexibly for the tenth to twelfth grades.	Mechanics, Power Machinery, Electrical and Electronics Engineering, Chemical Engineering, Civil Engineering and Architecture, Agricultural Science, Food Science, Fisheries and Aquatic Science, Marine Science
Biology	A	1-2	Depending on the situation of each school, the subject may be taught flexibly for the tenth to twelfth grades.	Mechanics, Power Machinery, Electrical and Electronics Engineering, Chemical Engineering, Civil Engineering and Architecture, Business and Administration, Foreign Language Studies, Design, Agricultural Science, Food Science, Home Economics Course Group, Hospitality-Major Category, Fisheries and Aquatic Science, Marine Science, Art
	B	4	Tenth grade	Agricultural Science

Descriptions:

1. Version B lists the basic courses of professional subjects suitable for all applicable study areas. Therefore, the suggested applicable study areas will not be adjusted. However, if the school already includes the MOE-mandated professional subjects for chemistry in its curriculum, the study area of Chemical Engineering can select version A or B of Chemistry.
2. A 4-credit course is recommended for the first and second semesters.
3. Version B of Physics is a 4-credit course. However, to fulfill the requirement for basic theory for the study area of Engineering, a school can add 2-credit courses in its school-developed curriculum, which reflect the learning demand of students' professional courses.
4. Each school may flexibly offer these courses, according to the traits of study areas, issue integration, students' career development, school development, or faculty allocation, etc. The total credits for this discipline are between 4-6 credits. Students should choose at least two or more subjects.

IV. Core Competency

The following table shows the specific content of Natural Science by following the specific content of the various educational stages core competency in the *General Guidelines* and combining them with the domain of Natural Science's Learning Focus and Core Competencies as in Appendix I.

Core Competency Dimension	**Core Competency Item**	**Item Description**	**Core Competencies of the domain of Natural Science（A version）**		
			Elementary School (E)	**Junior High School (J)**	**Vocational Senior High School (V.1-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	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 V.1-U-A1 Be interested in and passionate about exploring science. Develop a positive attitude towards science, and a habit of proactively learning new scientific knowledge and have the correct scientific attitude to inspire career planning and

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（A version）		
			Elementary School (E)	**Junior High School (J)**	**Vocational Senior High School (V.1-U)**
		in life, and continually strive for personal growth.			improve oneself.
	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 effectively tackle and solve problems in daily life.	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 known scientific knowledge, scientific concepts, and ways of exploring science and understand that there are different arguments, evidence or interpretations for science facts.	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 about or review credibility of problems, methods, information, or data and put forward possible solutions.	自 V.1-U-A2 Be able to cultivate the skills of collecting relevant information and conditions, and to reason and think logically in a scientific manner 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	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 V.1-U-A3 Be able to plan rationally to use scientific methods and execute plans with a scientific attitude. Actively respond to changes in life, work, or social changes.

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（A version）		
			Elementary School (E)	Junior High School (J)	Vocational Senior High School (V.1-U)
			for the learning stage to conduct natural science experiments.		
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, text, 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, text, pictures, drawings or physical objects, scientific terms, mathematical formulas, models, etc., to express the process, findings and results, values, and investigation's limitations.	自 V.1-U-B1 Be able to use language, words, and scientific symbols to think logically, express ideas, communicate differences, and understand others. Demonstrate the virtue of self-respect and respect for others, and apply them in daily life or work.
	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	自 V.1-U-B2 Be able to care about the development of natural sciences. Use various technological products and communication media to understand the latest developments and key issues in natural sciences without compromising personal data or the interests of the public or others. Have the skills of responding to or criticizing scientific issues reported in the media through analyzing diverse information

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（A version）		
			Elementary School (E)	**Junior High School (J)**	**Vocational Senior High School (V.1-U)**
				that is conducive to research and problem-solving.	and debates.
	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 V.1-U-B3 Be able to possess the attitude and ability to appreciate, construct and share the beauty of people and things. Admire scientists' creativity of building natural models and doing natural experiments. Appreciate the balance, stability, and beauty of the natural world.
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 V.1-U-C1 Cultivate knowledge and attitude of treating natural and marine resources well. Respect lives, and care for the local environment and technology. Be able to learn from science and its history and impact of development. Recognize that the development of science needs to take into account both ethical practice and sustainable human development. After learning about public issues and participating in social movements, have a sense of responsibility for the natural environment and resources.

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（A version）		
			Elementary School (E)	**Junior High School (J)**	**Vocational Senior High School (V.1-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 science-related knowledge and solving problems.	自 V.1-U-C2 Through group inquiry and discussion, develop a flexible attitude and broad perspective. Establish good interaction patterns with others. Be able to perceive prejudices, respect and tolerate differences. Establish friendly interpersonal relationships. Develop the ability to think critically, communicate, and participate together through cooperative learning. Be willing to take the initiative to acquire and share science-related knowledge.
	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 V.1-U-C3 Be able to have the competencies of identifying with one's own cultural identity and respecting and understanding multicultural differences among ethnic groups. Promote gender self-understanding and build respect for oneself and others. Through concern for global environmental and marine issues, understand differences of and interactions among each ecosystem and seas. At the same time, recognize that it is the responsibility of global citizens to

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（A version）		
			Elementary School (E)	Junior High School (J)	Vocational Senior High School (V.1-U)
					protect the earth, including marine resources. Then, promote sustainable human development through personal practice, social consensus and national policies.

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（B version）		
			Elementary School (E)	Junior High School (J)	Vocational Senior High School (V.2-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 Capable of using the five senses to exquisitely observe the surrounding environment, maintain curiosity and imagination to continue exploring nature.	自-J-A1 Capable of applying scientific knowledge, methods, and attitudes in daily life.	自 V.2-U-A1 Be able to develop an interest and enthusiasm for scientific exploration. Develop a positive attitude towards science. Cultivate the habit of actively learning about new scientific knowledge. Actively explore the operation modes of nature and related scientific theories. Possess a correct scientific attitude to inspire career planning, self-pursuit, and aspirations for science.
	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	自-E-A2 Capable of using curiosity and imagination, from information or data obtained through observation, reading, and thinking, to ask questions or explain	自-J-A2 Capable of linking acquired scientific knowledge with observed natural phenomena and experimental data. Learn to explore evidence by self or	自 V.2-U-A2 Be able to develop the ability to collect relevant information and conditions. Use scientific knowledge and methods to analyze, reason, and think logically.

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（B version）		
			Elementary School (E)	**Junior High School (J)**	**Vocational Senior High School (V.2-U)**
		ability to reflect and conduct actions, to effectively tackle and solve problems in daily life.	data suitable for scientific inquiry. Be able to imagine possibilities of events based on known scientific knowledge, scientific concepts, and ways of exploring science. Understand that there are different arguments, evidence or interpretations for scientific facts.	in groups. Respond to multiple viewpoints, have reasonable doubts, or review the credibility of problems, methods, information, or data. Propose possible solutions to problems.	Conduct experiments, investigate and reflect on theories. Be able to use scientific theories and multiple 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 Capable of exploring scientific problems through hands-on exploration activities, and able to formulate simple steps and operate equipment, technological devices, and resources suitable for the learning stage based on the characteristics of the problem and the availability of resources, and conduct natural science experiments.	自-J-A3 Capable of identifying problems from daily life experience and being able to make good use of surrounding objects, equipment, technological devices, and resources in life to plan natural science exploration activities according to the characteristics of the problem, resources, and other factors.	自 V.2-U-A3 Be able to cultivate and learn the knowledge of nature. Be concerned with the future development trends of science. Dare to face the future world with an innovative attitude of flexible adaptation. Be able to make rational plans with scientific knowledge and methods. Implement plans with a scientific attitude. Actively respond to changes in life or work and social changes.
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	自-E-B1 Be able to analyze, compare, create diagrams, use simple mathematics, and other methods to organize existing natural science information or data. Use simpler forms of verbal, words, video, drawings or physical objects, scientific terms, mathematical formulas, models, etc., to express the process,	自-J-B1 Possess the ability of analyzing, summarizing, creating charts and graphs, using information and mathematical operations, and other methods to organize natural scientific information or data. Use spoken words, visual media, text, pictures, drawings or physical objects,	自 V.2-U-B1 Be able to use language, words, and scientific symbols to reason, think logically, express ideas, communicate, and share with others in daily life or work.

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（B version）		
			Elementary School (E)	**Junior High School (J)**	**Vocational Senior High School (V.2-U)**
		or at the workplace.	findings or results of investigations.	scientific terms, mathematical formulas, models, etc., to express the process, findings and results, values, and investigation's limitations.	
	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 are used, identify problems or obtain information useful for exploration from learning activities, daily experiences, and use of technology, natural environment, books, online media, etc.	自-J-B2 Be able to operate technological equipment and resources suitable for the learning stage. Develop relevant ethics and discriminate the credibility of information. Conduct various planned observations from learning activities, daily experience. Use technology, natural environment, books, and online media, to obtain information that is useful for exploration and problem-solving.	自 V.2-U-B2 Be able to be concerned about information on the development of natural science. Make good use of various technological products and communication media to understand the latest developments and key issues in natural science without compromising the safety of personal data or the interests of the public or others. Be able to respond to or criticizing science-related issues reported in the media through multi-information analysis and discernment.
	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 Use 5 senses to observe animals, plants, and natural phenomena in the surrounding environment and know how to appreciate beautiful things.	自-J-B3 Experience the beauty of nature and life by admiring the mountains and the earth, wind, clouds, rain and dew, rivers, seas and oceans, and the sun, the moon, and stars.	自 V.2-U-B3 Possess the attitude and skills of appreciating, constructing and sharing the beauty of people and things. Appreciate the rigorous and rich underlying meaning of theories in natural sciences. Admire the creativity of scientists in building natural models and designing

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（B version）		
			Elementary School (E)	**Junior High School (J)**	**Vocational Senior High School (V.2-U)**
					natural experiments. Further, appreciate the balance, stability, and beauty of the natural world.
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 Care about and take actions to cherish nature, life and resources.	自-J-C1 From everyday learning, take the initiative to care about public issues related to the natural environment and respect life.	自 V.2-U-C1 Cultivate knowledge and attitude of treating natural and marine resources well, respecting lives, and caring for the local environment and technology. Be able to learn from science and its history and impact of development. Recognize that the development of science needs to take into account both ethical practice and sustainable human development. After learning about public issues and participating in social movements, have a sense of responsibility for the natural environment and resources.
	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	自-E-C2 Through collaborative learning in science exploration, develop the skills of communicating, expressing, working as a team, and getting along with peers.	自-J-C2 Through collaborative learning, develop the skills of communicating, participating in, conducting, discovering scientific knowledge, and solving problems together with peers.	自 V.2-U-C2 Through group investigation and discussion, develop a flexible attitude and broad perspective and form good interaction patterns with others. Be able to perceive prejudices, respect and tolerate differences and build friendly interpersonal relationships. Through the cooperation of

Core Competency Dimension	Core Competency Item	Item Description	Core Competencies of the domain of Natural Science（B version）		
			Elementary School (E)	**Junior High School (J)**	**Vocational Senior High School (V.2-U)**
		teamwork.			learning science process, develop the ability to think, communicate and participate together. Enhance the interest and enthusiasm in exploring science and be willing to share the acquired scientific knowledge with other team members.
	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 learning about environment-related issues, understand current status and characteristics of the global natural environment and their cultural differences.	自-J-C3 Through learning about environment-related issues, understand interactions among diverse global natural environment, and develop one's own cultural identity and values as a global citizen.	自 V.2-U-C3 Be able to have the competencies of identifying with one's own cultural identity and respecting and understanding multicultural differences among ethnic groups. Promote gender self-understanding and build respect for self and others. Through concern for global environmental and marine issues, understand differences of and interactions among each ecosystem and seas. At the same time, recognize that it is the responsibility of global citizens to protect the earth, and marine resources. Then, promote sustainable human development through personal practice, social consensus and national policies.

V. Learning Focus

Grounded upon the essential ideas and curriculum goals of fostering science competency, the learning focus of the discipline includes: the core concepts of science, the ability to explore, the attitude, and the nature of science. The curriculum of vocational senior high school should integrate the following aspects: the traits of the mind and body of students, and the needs of society and daily life. The “Inquiry ability” and the “Attitude toward science and nature of science” are the “Learning performance” of students, and the “Core concepts of science” aims to present the substantive “Learning content” of science.

The “Learning performance” and “Learning content” of this discipline are interconnected. The former refers to the expected learning performance of scientific exploratory skills and scientific attitude the student has when facing science-related issues. The latter indicates the systematic scientific knowledge of the natural world that humans have accumulated, that students obtain as the starting point of their inquiry and problem-solving process. The natural science curriculum should guide the students to learn scientific inquiry skills and foster scientific attitudes throughout different approaches like reading, observation, exploration, experiment, and practice, so that they can obtain the understanding and pragmatic abilities of scientific knowledge.

According to the traits of mind and body development of students, the learning focus of the natural science discipline connects the 12-Year Basic Education horizontally and vertically. For essential cognitive ability, the natural science discipline of vocational senior high schools covers three major topics: “Composition and characteristics of the natural world,” “Phenomenon and the mechanism of the natural world,” and “Sustainable development of the natural world.” Please see “**The Structure of the Learning Content of the Natural Sciences Discipline**” for more details. The “Inquiry ability” consists of two aspects: Thinking ability and Problem-solving. The “Attitude toward science and nature of science” includes three main aspects: “Cultivate interest in scientific inquiry,” “Develop the habit of applying scientific thinking and inquiry,” and “Understanding the nature of science.” The learning content and performances of vocational senior high schools follow with the core concepts, “Inquiry ability” and “Attitude toward science and nature of science" of the natural science discipline. Version A and Version B are designed for the different characteristics and needs of the different study areas.

The Structure of the Learning Content of the Natural Sciences Discipline

Theme	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 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 the 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)

Theme	Cross-subject Concepts	Topics	Sub-Topics
			Electromagnetic phenomena (Kc) Quantum phenomena (Kd) 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)

1. Learning Performance

(1) The coding method of the learning performance is described as follows: The first code is for "Items", which is divided into three codes (shown ~~as~~ on the following table); the second code is for the A or B version of technical senior high school (**V.1** is for A version — **V.2** is for B version); the third code is a serial number, which represents the target level of each item.

(2) The "inquiry ability" covers basic cognitive abilities, such as: perception, memory, imagination, distinct discrimination, analysis, thinking, reasoning, judgment, and creativity, etc. The "learning performance" of each stage identifies the development of the related abilities.

Items	The Code of Performances Category
Inquiry ability - Thinking ability	1
Inquiry ability - Problem-solving	2
Attitude towards science and the nature of science	3

A. Learning performance in A version

Items	Sub-items	Learning Performance		Specific Description
Inquiry ability—Thinking ability	Imagination and creativity	1-V.1-1	Students can perceive problems proactively; and so design scientific explorations, and experiments.	Students can perceive the causes of various science problems in life proactively, including the causes of human rights, gender, environment, and ocean issues. They can propose various hypothetical ideas for solving problems based on known scientific knowledge. Furthermore, students can design scientific explorations and experimental methods individually or in groups.
	Reasoning and argumentation	1-V.1-2	Students can use single science evidence or theory to understand causality and then propose different arguments.	Students can use simple mathematical algorithm formulas and single science evidence or theory to understand the causes or causal relationships of science knowledge or theory, as well as issues of human rights, gender, the environment, and the ocean. Furthermore, students can put forward the limitations of others' arguments and then propose different arguments.
	Critical thinking	1-V.1-3	Students can ask questions or use critical thinking.	Students can compare scientific facts and the rationality of different arguments, evidence, or facts on human rights, gender, the environment, and the ocean. Students can judge the correctness of scientific evidence and the importance of a topic by exploring the evidence, challenging ideas, and responding to multiple perspectives.
	Construction of models	1-V.1-4	Students can understand models and the limitations of models.	Students can build a model based on science issues through self-contained or collaborative discussions. Students can describe a systematic science phenomenon by using a model form such as “comparative or abstract,” and understand that the model has limitations.
Inquiry ability Problem-solving	Observing and identifying	2-V.1-1	Students can identify problems and solve them scientifically.	Students can observe problems from experience in daily life, socio-scientific issues (including human rights, gender, the environment and the ocean), learning activities, the natural environment, books, and online media. Students can ask questions (or make hypotheses) about their lives that are appropriate for scientific inquiry or for scientific resolution, using skills such

Items	Sub-items	Learning Performance		Specific Description
				as: observation, data collection, reading, thinking ,and discussing, etc.
	Planning and executing	2-V.1-2	Students can plan optimal problem-solving activities and operate equipment correctly and safely.	Students can plan optimal inquiry, problem-solving, or reasoning activities based on factors such as problem characteristics, learning resources (equipment, time, manpower, etc.), expected outcomes, and impact on the social environment through the guidance of teachers, textbooks or the presentation of ideas. Students can correctly and safely operate items such as, equipment, technology equipment, and resources that are suitable for the learning stage, and can innovate and modify implementation modes when necessary.
	Analyzing and finding	2-V.1-3	Students can use reason, intelligence and critical thinking skills to compare and check relevant information and results.	Students can effectively organize information or data using reasonably thinking intelligence, making charts, mathematics, statistics, etc. Using the information or data obtained from the inquiry process, students can elaborate; thinking, discover new knowledge; learn about cause and effect; understand scientific society, human rights, gender, the environment and the ocean; solve problems or discover new problems. Students can compare the results of their own inquiry with other related information. Students can check and confirm each other's results collaboratively.

Items	Sub-items	Learning Performance		Specific Description
	Discussing and communicating	2-V.1-4	Students can evaluate the inquiry process and formulate evaluations. Students can also propose and share reasonable improvements to plans.	Students can understand the process and results of their classmates' inquiries and raise reasonable and more complete questions or opinions. And they can assess the whole process of inquiry, formulate evaluations, and suggest reasonable solutions for improvement. Students can present the process, findings or results of inquiry using written or spoken language, images (e.g., photography, video), text and graphics, drawings or objects, scientific terms, and models, etc. Students can attempts to communicate with others and share the importance of issues including: human rights, gender, the environment, and the oceans. They can maintain personal security and avoid violating the rights of others or the public. And they can share relatively rigorous findings and results in the broader context of new media.
Attitude towards science and nature of science	Cultivate interest in scientific inquiry	3-V.1-1	Students can understand the diversity of science abilities, and achieve a sense of accomplishment through problem-solving.	Students can understand the diversity of science abilities. And they can know that enthusiasm is an essential condition for engaging in science or technology related work. Through scientific exploration and thinking, students will have new experiences of things around them, and achieve a sense of accomplishment through successful experience in solving problems.
	Develop the habit of applying scientific thinking and inquiry	3-V.1-2	Students can keep a critical attitude towards scientific information and examine its authenticity and credibility.	Students can understand that scientific knowledge is an explanation for people's understanding of phenomena, but it is not the only explanation. The science community often chooses different interpretations according to specific criteria (such as generalization, simplicity, etc.). Students can keep a critical attitude towards scientific information in daily life, and carefully examine its authenticity and credibility.
	Understanding the nature of	3-V.1-3	Students can understand that	The difference between science and other ways of knowing the world lies

Items	Sub-items	Learning Performance	Specific Description
	science	science is based on logical thinking and critical reviews.	in the use of empirical standards, logical arguments, and question-based examinations. The effectiveness of scientific arguments can be enhanced by using different evidence to support particular interpretations. Scientific knowledge is historical, and scientific knowledge and beliefs may change over time.

B. Learning performance in B version

Items	Sub-items	Learning Performance	Specific Description
Inquiry ability—Thinking ability	Imagination and creativity	1-V.2-1 Through cultivating perceptual ability and imagination in the learning process, students continue exploration and experimentation and then develop innovative ideas and designs.	Students can independently detect the causes of various science problems in life, and can think of different hypotheses and feasible solutions according to different situations. In addition, they can individually or collaboratively design different experimental steps or create new experimental methods.
	Reasoning and argumentation	1-V.2-2 Students can make qualitative and quantitative judgments and descriptions, explain phenomena, results, relevance, and differences using acquired knowledge, and can then infer the causal relationships of natural phenomena.	Students can use known mathematical calculus formulas and single pieces of scientific evidence or theory. Students can use analogy, transformation, and other deductive reasoning methods to understand and derive the causal relationships of natural phenomena, or to explain and correct their arguments.

Items	Sub-items	Learning Performance		Specific Description
	Critical thinking	1-V.2-3	Students can hold reasonable doubt about the correctness of collected scientific data and information. Using judgment and speculation, students can present their own opinions or explanations from different perspectives.	Students can compare the rationality of scientific facts with different arguments, evidence, or factual interpretations. And they can judge the correctness of scientific evidence by examining the evidence, challenging ideas, and responding from multiple perspectives.
	Construction of models	1-V.2-4	Students can understand models of scientific principles. And they can understand scientific principles and explain scientific phenomena by choosing, building, applying, and using models.	Students can build a model based on scientific issues through independent or collaborative discussions. Students can use model forms, such as "comparative or abstract," to describe a systematic scientific phenomenon and then understand that the models can be modified or corrected as their perception of the complicated relationship of science increases.
Inquiry ability Problem-solving	Observing and identifying	2-V.2-1	Students often observe and gather the information needed based on their curiosity or knowledge, as well as the need to clarify and define issues that require inquiry or resolution.	1. Students can further recognize problems by systematically observing their learning activities, daily experiences, technological applications, the natural environment, and printed and social media. 2. Students can judge if a problem or hypothesis is suitable for inquiry or can be resolved using scientific approaches. And, they can offer proper questions based on observation, data collection, reading, thinking, and discussion. When there are multiple problems at the same time, students can distinguish and prioritize the problems or hypotheses.

Items	Sub-items	Learning Performance		Specific Description
	Planning and executing	2-V.2-2	After the problem is determined, the student can draft the project, predict the results, and proceed with scientific inquiry through tests, measurements, reasoning, and calculation to obtain scientific evidence.	1. Students can discern independent variables from dependent variables, plan experiments, and predict possible results carefully. Under the guidance of teachers, textbooks, or other resources, students can understand the task at hand and efficiently formulate reliable inquiry activities (e.g., multiple trials) according to elements such as types of questions and resources (e.g., equipment and time). 2. Students can accurately and safely operate tools, equipment, and resources that are suitable for their particular learning stage. Students can conduct objective qualitative observations or make statistical measurements and record them faithfully.
	Analyzing and finding	2-V.2-3	Students can analyze qualitative evidence or quantitative data through the results of the inquiry, discover new knowledge or solve problems, and compare their results with the results of other related inquiries.	1. Students can apply methods such as analysis of induced graphs, information, and mathematics to organize information or data. 2. Students can formulate explanations, discover unknown knowledge, understand scientific issues, obtain causal relations, solve problems, or identify questions through the received information or data. Meanwhile, they can compare their inquiry results with classmates' results or other relevant information, and cross-evaluate differing results. If the final results are still different, the students can explore the reasons further.

Items	Sub-items	Learning Performance		Specific Description
	Discussing and communicating	2-V.2-4	Students can discuss, evaluate and communicate the results of an inquiry or the outcome of a problem.	1. Students can understand classmates' inquiry processes and outcomes (or simplified scientific reports), then offer~~ing~~ reasonable and justified questions or opinions. Furthermore, they can cross-examine the consistency level between the inquiry process components (question identification, scientific practice, data analysis, use of evidence, activity safety, and inquiry outcomes) and then suggest potential ways to improve. 2. Students can utilize spoken and written language, images (e.g., photography, recording), pictures, drawings or concrete objects, scientific terms, mathematic algorithms, or models to present their inquiries, findings, and outcomes. Students can choose the appropriate method and means of publication, maintain the privacy and security of individuals and data, and avoid harm to others or to the public interest.
Attitude towards science and nature of science	Cultivate interest in scientific inquiry	3-V.2-1	Students can recognize the diversity of science and technology-related undertakings by understanding the relationships between science, technology, and society. Furthermore, students can generate interest in applied science to solve real-world problems and so, enhance their motivation to learn science.	1. Through scientific exploration and scientific thinking, students can gain new experiences of the things in everyday life and technology. 2. Students can learn to appreciate the beauty of science by understanding the simplicity of the theory of science, the rigor of scientific thinking, and the laws behind complex natural phenomena. 3. Students can understand the diversity of science and technology-related undertakings. Through scientific exploration, scientific thinking, and life experiences, students can try to change the application of technology and gain a sense of accomplishment through successful experience solving problems.

Items	Sub-items	Learning Performance		Specific Description
	Develop the habit of applying scientific thinking and inquiry	3-V.2-2	Students can develop habits of critical thinking and using the value system of science to evaluate the information in daily life.	1. Students can understand that scientific knowledge is an explanation for people's understanding of phenomena, but it is not the only explanation. 2. Students can use standards, such as logical thinking, accuracy, and objectivity to evaluate the credibility of scientific information in daily life.
	Understanding the nature of science	3-V.2-3	Students can understand the diversity of scientific arguments and distinguish between scientific and non-scientific values through the use of critical thinking.	1. Scientific knowledge is historical, and scientific knowledge and beliefs can change over time. 2. The difference between science and other ways of knowing the world lies in the use of empirical standards, logical arguments, and question-based examinations. 3. Science can explain the same natural phenomenon with more than one theory. If the existing evidence supports these different theories, scientists tend to adopt the most straightforward theory.

2. Learning Content

The coding method of the learning content is as follows: The first code is for the topic and subtopics of the science subject (Physics P, Chemistry C, Biology B); the second code is for the A and B versions (the A version is V.1; the B version is V.2); The third code is a serial number.

(1) Physics

A. Learning content of Physics—A version

The learning content of Physics—A version is as follows:

The same learning content may cover the contents of different subtopics.

Topics	Subtopics	Learning Content	
Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba)	PBa-V.1-1	Form of energy.
		PBa-V.1-2*	The relationship between energy and force.
		PBa-V.1-3	Energy conversion and energy conservation.
	Temperature and	PBb-V.1-1	Temperature and heat (*description of

Topics	Subtopics	Learning Content	
	heat (Bb)		evaporation).
Physical systems (E)	Scales and units of nature（Ea）	PEa-V.1-1	Physical quantity measurement and unit.
		PEa-V.1-2	Scales of nature.
	Force and movement (Eb)	PEb-V.1-1	Motion in daily life.
		PEb-V.1-2	Force and its effects.
		PEb-V.1-3	Force in daily life (*calculation of friction).
Phenomena and interactions in nature (K)	Waves, light, and sound (Ka)	PKa-V.1-1	The phenomenon of waves.
		PKa-V.1-2	The sound and the spread of sound.
		PKa-V.1-3	Music tone and noise.
		PKa-V.1-4*	Reflection of light and mirror imaging.
		PKa-V.1-5*	Refraction of light and lens imaging.
		PKa-V.1-6	Light and life.
	Universal gravitation (Kb)	PKb-V.1-1	Force.
	Electromagnetic phenomena（Kc）	PKc-V.1-1	Understanding of electricity.
		PKc-V.1-2	Direct current (DC) and alternating current (AC).
		PKc-V.1-3	The thermal effects of current and applications in life.
		PKc-V.1-4	The magnetic effect of current and applications in life.
		PKc-V.1-5*	The electromagnetic induction phenomenon and applications in life.
		PKc-V.1-6	Electricity and safety.
		PKc-V.1-7	Electromagnetic waves.
	Quantum phenomena（Kd）	PKd-V.1-1	The application of physics in life.
	Basic interactions (Ke)	PKe-V.1-1*	The fundamental interaction.
Science, technology, society, and humanities（M）	Relationship between science, technology and society (Ma)	PMa-V.1-1	The relationship between physics and other basic sciences.
	History of science development (Mb)	PMb-V.1-1	A brief history of physics.
	Application of science in daily life (Mc)	PMc-V.1-1	The application of physics in life.
Resources and sustainable development (N)	Development and utilization of energy (Nc)	PNc-V.1-1	Effective use and conservation of energy.

B. Learning content of Physics—B version

Topics	Subtopics	Learning Content	
Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba)	PBa-V.2-1	Work and power.
		PBa-V.2-2	Mechanical energy (* calculation of elastic potential energy) and (* calculation of conservation of mechanical energy).
		PBa-V.2-3	Energy conversion.
	Temperature and heat (Bb)	PBb-V.2-1	The concepts of temperature and thermal equilibrium.
		PBb-V.2-2	Specific heat and heat capacity.
		PBb-V.2-3	Latent heat and changing states of matter.
		PBb-V.2-4	Thermal expansion (* coefficient of thermal expansion).
		PBb-V.2-5*	Law of thermodynamics
Physical systems (E)	Scales and units of nature（Ea）	PEa-V.2-1	Introduction of SI units.
	Force and movement (Eb)	PEb-V.2-1	Physical quantity related to motion.
		PEb-V.2-2	Acceleration and uniformly accelerated motion.
		PEb-V.2-3	Freely falling bodies.
		PEb-V.2-4	Vector on a plane.
		PEb-V.2-5*	Projectile movements.
		PEb-V.2-6	Uniform circular motion.
		PEb-V.2-7	The meaning of force and its measurement.
		PEb-V.2-8	Newton's law of motion.
		PEb-V.2-9	Friction.
		PEb-V.2-10	Momentum and impulse.
		PEb-V.2-11	Conservation of momentum.
		PEb-V.2-12*	Collision.
		PEb-V.2-13	The pressure and buoyancy of a stationary liquid.
		PEb-V.2-14	Pascal's principle and its application.
		PEb-V.2-15	Atmospheric pressure.
Phenomena and interactions in nature (K)	Waves, light, and sound (Ka)	PKa-V.2-1	Vibration and waves.
		PKa-V.2-2	Reflection and transmission of rope waves.
		PKa-V.2-3	The characteristics of a wave.
		PKa-V.2-4*	Resonance and standing waves.
		PKa-V.2-5	Sound waves (* Doppler effect).
		PKa-V.2-6	The reflection of light.
		PKa-V.2-7	The refraction of light.
		PKa-V.2-8	The interference of light.
		PKa-V.2-9*	The diffraction of light.
	Universal gravitation（Kb）	PKb-V.2-1	Universal gravitation

Topics	Subtopics	Learning Content	
	Electromagnetic phenomena（Kc）	PKc-V.2-1	The phenomenon of static electricity
		PKc-V.2-2	Electric field and electric field lines.
		PKc-V.2-3*	The force and motion of a charged body.
		PKc-V.2-4	Electric potential energy, electric potential, and potential difference.
		PKc-V.2-5	The electric field and potential difference across two parallel plates.
		PKc-V.2-6*	Capacitance.
		PKc-V.2-7	Current, resistance, and Ohm's law.
		PKc-V.2-8*	Kirchhoff's law.
		PKc-V.2-9	The thermal effect of the current and the electric power.
		PKc-V.2-10	Electricity and safety.
		PKc-V.2-11	The magnetic effect of an electric current.
		PKc-V.2-12	The magnetic field of a current-carrying wire.
		PKc-V.2-13	The force on a current-carrying wire in a magnetic field and its application.
		PKc-V.2-14*	The motion of a charged particle in a magnetic field and its application.
		PKc-V.2-15	Faraday's laws of electromagnetic induction and Lenz's law.
		PKc-V.2-16	The Eddy current phenomenon and principle of the transformer.
		PKc-V.2-17*	Generators and alternating current.
		PKc-V.2-18	Electromagnetic waves.
	Quantum phenomena（Kd）	PKd-V.2-1	Quantum theory.
		PKd-V.2-2	Photoelectric effect.
		PKd-V.2-3	Atomic structure and spectrum (* the energy levels of a Hydrogen atom).
		PKd-V.2-4*	Matter waves.
		PKd-V.2-5	Wave-particle duality (* Experimental explanation of matter-waves).
	Basic interactions (Ke)	PKe-V.2-1	Fundamental interaction.
Science, technology, society, and humanities（M）	Relationship between science, technology and society (Ma)	PMa-V.2-1	The relationship between physics and other basic sciences.
	History of science development (Mb)	PMb-V.2-1	A brief history of physics.
	Application of science in daily life（Mc）	PMc-V.2-1	The application of physics in life.
Resources and sustainable	Development and utilization of	PNc-V.2-1	Nuclear energy.

Topics	Subtopics	Learning Content
development (N)	energy (Nc)	

(2) Chemistry

A. Learning content of Chemistry—A version

The Chemistry A version of the learning content standard is a 1-credit course.

Topics	Subtopics	Learning Content	
Earth environment (F)	The materials of the Earth (Fa)	CFa-V.1-1	Matter in nature: Natural circulation.
		CFa-V.1-2	Properties of water and its impact.
		CFa-V.1-3	Water quality; elutriation, purification, and softening of water.
		CFa-V.1-4	Marine resources.
		CFa-V.1-5	Matter in the air.
		CFa-V.1-6	Soil formations, compositions and applications.
Reactions of the materials, equilibrium and production (J)	Changes in aqueous solution (Jb)	CJb-V.1-1	Experiment: weather bottle.
	Acid-base reactions (Jd)	CJd-V.1-1	Experiment: homemade mine.
Science, technology, society, and humanities (M)	Relationship between science, technology and society (Ma)	CMa-V.1-1	Modern industry and chemistry: polymer chemistry and the petrochemical industry.
		CMa-V.1-2	Biotechnology industry.
	History of science development (Mb)	CMb-V.1-1	History of chemistry development.
	Application of science in daily life (Mc)	CMc-V.1-1	Food and chemistry in daily life.
		CMc-V.1-2	Experiment: detection of antioxidants in tea and juice.
		CMc-V.1-3	Clothing and chemistry.
		CMc-V.1-4	Soap and detergent.
		CMc-V.1-5	Materials and chemistry: plastics.
		CMc-V.1-6	Experiment: Slug (polymers from copolymerization of borax, distilled water, and glue).
		CMc-V.1-7	Ceramic, tiles and glass.
		CMc-V.1-8	Nano-materials and advanced materials.
		CMc-V.1-9	Medicine and chemistry.
	Environmental pollution and prevention (Me)	CMe-V.1-1	Water pollution and prevention.
		CMe-V.1-2	Air pollution and prevention.
		CMe-V.1-3	Soil pollution and prevention.
Resources and sustainable development (N)	Development and utilization of energy (Nc)	CNc-V.1-1	Principles of chemical batteries.
		CNc-V.1-2	Common batteries.
		CNc-V.1-3	Experiment: chemical battery.
		CNc-V.1-4	Alternative Energy.

Topics	Subtopics	Learning Content	
		CNc-V.1-5	Introduction of renewable energy in Taiwan and the preservation and development of energy resources in nearby sea areas.

B. Learning content of Chemistry—B version

The learning content of Chemistry—B version is as follows:

The same learning content may cover the contents of different subtopics.

Topics	Subtopics	Learning Content	
Composition and characteristics of matter (A)	Composition of matter/materials and periodicity of elements (Aa)	CAa-V.2-1	Atoms and molecules (*the law of definite proportion and the law of multiple proportions)
		CAa-V.2-2	Atomic weight and molecular weight.
		CAa-V.2-3	Atomic structure.
		CAa-V.2-4	The arrangement of electrons in an atom.
		CAa-V.2-5	Regularity and periodicity of the elements.
		CAa-V.2-6	Periodic table of the elements.
	Form, properties, and classification of matter/materials (Ab)	CAb-V.2-1	Three-phase diagram of matter.
		CAb-V.2-2	Classifications of matters.
Form, conversion, and flow of energy (B)	Form and conversion of energy (Ba)	CBa-V.2-1	The energy changes in chemical reactions (*Hess' law).
Structure and function of matter/materials (C)	Separation and classification of matter/materials (Ca)	CCa-V.2-1	Separation and characterization of substances.
	Structure and function of matter/materials (Cb)	CCb-V.2-1	Chemical formula.
		CCb-V.2-2*	Determination of chemical formula.
		CCb-V.2-3	Structures of substances.
		CCb-V.2-4	Experiment: molecular modeling.
Physical systems (E)	Gas (Ec)	CEc-V.2-1	Properties of gases.
		CEc-V.2-2	Empirical gas laws, (*absolute temperature, measurements using open and closed gas manometers).
		CEc-V.2-3*	Ideal gas.
		CEc-V.2-4*	Partial pressure.
Earth environment (F)	The materials of the Earth (Fa)	CFa-V.2-1	Natural circulation.
		CFa-V.2-2	Properties of water and its impact.
		CFa-V.2-3	Water quality; elutriation, purification, and softening of water.
		CFa-V.2-4	Marine resources.
		CFa-V.2-5	Matter in the air (*inert gases krypton,

Topics	Subtopics	Learning Content	
			xenon, and radon.)
		CFa-V.2-6	Soil formation, composition, and applications.
Reactions of the materials, equilibrium and production (J)	Law of material reactions (Ja)	CJa-V.2-1	The Chemical equations.
		CJa-V.2-2	Stoichiometric quantity.
	Changes in aqueous solution (Jb)	CJb-V.2-1	Aqueous solution.
	Oxidation and reduction reactions (Jc)	CJc-V.2-1	Oxidation and reduction reactions.
	Acid-base reactions (Jd)	CJd-V.2-1	Acid-base reactions.
	Chemical reaction rate and equilibrium (Je)	CJe-V.2-1	The definition of reaction rate.
		CJe-V.2-2*	Reaction rate law; reaction rate constant; zero-order, first-order, and second-order reactions.
		CJe-V.2-3*	Collision theory.
		CJe-V.2-4	Factors affecting the reaction rate.
		CJe-V.2-5	Reversible reaction and dynamic equilibrium.
		CJe-V.2-6*	The definition of the equilibrium constant (Kc, Kp); equilibrium constant expression.
		CJe-V.2-7	Factors affecting equilibrium.
		CJe-V.2-8*	Le Châtelier's principle.
		CJe-V.2-9*	Equilibrium in dissolution.
	*Properties, preparation and reactions of organic compounds (Jf)	CJf-V.2-1*	Alkanes, alkenes, alkynes and cycloalkanes: structures and properties.
		CJf-V.2-2*	Isomers.
		CJf-V.2-3*	Simple nomenclature for organic compounds.
		CJf-V.2-4*	Aromatic compounds.
		CJf-V.2-5*	Common organic functionality: basic properties, reactions and applications.
		CJf-V.2-6*	Preparation of some common organic compounds.
		CJf-V.2-7*	Experiment: properties of organic compounds.
Science, technology, society, and humanities (M)	* Relationship between science, technology and society (Ma)	CMa-V.2-1*	The interaction of science, technology, and society.
	*History of science development (Mb)	CMb-V.2-1*	The history of chemical development.
	Application of science in daily life (Mc)	CMc-V.2-1	Food and chemistry. (*tea, coffee, vitamins, minerals.)
		CMc-V.2-2	Clothing and chemistry.
		CMc-V.2-3	Soap and detergent.

Topics	Subtopics	Learning Content	
		CMc-V.2-4	Materials and chemistry: plastic.
		CMc-V.2-5	Experiment: Slug (polymers from copolymerization of borax, distilled water, and glue).
		CMc-V.2-6	Ceramic, tiles and glass.
		CMc-V.2-7	Nano-materials and advanced materials (*metal or ceramic composites, photoresists, electronic packaging materials, colorants).
		CMc-V.2-8	Medicine and chemistry.
	*Natural disasters and prevention (Md)	CMd-V.2-1*	Natural disasters and prevention.
	Environmental pollution and prevention (Me)	CMe-V.2-1	Water pollution and prevention.
		CMe-V.2-2	Air pollution and prevention.
		CMe-V.2-3	Soil pollution and prevention.
Resources and sustainable development (N)	* Sustainable development and utilization of resources (Na)	CNa-V.2-1*	Green chemistry (chemical industry) and environmental and sustainable development (conservation, utilization, and reuse of resources).
	* Climate change impact and adaptation (Nb)	CNb-V.2-1*	The impact and adaptation of climate change.
	Development and utilization of energy (Nc)	CNc-V.2-1	Fossil fuels: coal, oil, natural gas, shale oil.
		CNc-V.2-2	Petroleum fractionation and its main products.
		CNc-V.2-3	Hydrocarbon combustion and gasoline octane number.
		CNc-V.2-4	Principle of chemical batteries.
		CNc-V.2-5	Common batteries.(*dry batteries, alkaline batteries.)
		CNc-V.2-6	Experiment: chemical battery.
		CNc-V.2-7	Alternative energy.
		CNc-V.2-8	Introduction of renewable energy in Taiwan and the preservation and development of energy resources in nearby Taiwan sea areas.

(3)Biology

A. Learning content of Biology—A version

The learning content of Biology—A version is as follows:

The same learning content may cover the content of different subtopics.

Topics	Subtopics	Learning content	
Form, conversion, and flow of energy (B)	Energy and metabolism in organisms (Bc)	BBc-V.1-1	Nutrition and digestion.
		BBc-V.1-2*	Inquiry activity: food safety and testing.
Structure and function of organisms (D)	Structure and function of cells (Da)	BDa-V.1-1	Nerves and exercise.
	Structure and function of plants and animals (Db)	BDb-V.1-1	Circulation.
		BDb-V.1-2	Respiration and excretion.
		BDb-V.1-3	Defense.
	Homeostasis and regulation of living organisms (Dc)	BDc-V.1-1	Hormone and coordination.
Evolution and heredity (G)	Reproduction and inheritance (Ga)	BGa-V.1-1	Human reproduction.
		BGa-V.1-2	DNA, genes, and chromosomes.
		BGa-V.1-3	The inheritance of blood type.
		BGa-V.1-4	Sexual inheritance.
		BGa-V.1-5*	The common hereditary diseases.
		BGa-V.1-6*	Inquiry activity: DNA extraction.
	Biodiversity (Gc)	BGc-V.1-1	Introduction of biodiversity.
		BGc-V.1-2	Introduction of microorganisms.
Organisms and the environment (L)	Interaction between organisms (La)	BLa-V.1-1	Invasion of alien species.
Science, technology, society, and humanities (M)	Relationship between science, technology and society (Ma)	BMa-V.1-1*	Traditional biotechnology.
		BMa-V.1-2	Genetically modified organisms and food.
	History of science development (Mb)	BMb-V.1-1	Antibiotics and vaccines.
	Application of science in daily life (Mc)	BMc-V.1-1*	Human transplantation technology.
		BMc-V.1-2*	Inquiry activity: to discuss the safety and ethical issues of biotechnology
	Natural disasters and prevention (Md)	BMd-V.1-1	Natural disasters, environmental pollution and prevention (natural disasters).
	Environmental pollution and prevention (Me)	BMe-V.1-1	Natural disasters, environmental pollution and prevention (environmental pollution).
Rresources and sustainable development (N)	Sustainable development and utilization of resources (Na)	BNa-V.1-1	Ecological engineering methods.
		BNa-V.1-2	Conservation and sustainable management of biodiversity.
		BNa-V.1-3	Resource recycling and reuse.
	Development and	BNc-V.1-1	Biomass energy.

Topics	Subtopics	Learning content
	utilization of energy (Nc)	

B. Learning content of Biology—B version

The Biological B version of the learning content standard is a 4-credit course.

Topics	Subtopics	Learning Content	
Form, conversion, and flow of energy (B)	Energy and metabolism in organisms (Bc)	BBc-V.2-1	The phenomenon of life.
Structure and function of organisms (D)	Structure and function of cells (Da)	BDa-V.2-1	Cells.
		BDa-V.2-2	Cell division.
		BDa-V.2-3	Inquiry activity: observation of animal cells and plant cells.
	Structure and function of plants and animals (Db)	BDb-V.2-1	The structure and function of plants.
		BDb-V.2-2	The physiology of plants.
		BDb-V.2-3	Nutrition and digestion.
		BDb-V.2-4	Circulation.
		BDb-V.2-5	Respiration and excretion.
		BDb-V.2-6	Defense.
		BDb-V.2-7	Nerves and exercise.
	Homeostasis and regulation of living organisms (Dc)	BDc-V.2-1	Hormone and coordination.
Evolution and heredity (G)	Reproduction and inheritance (Ga)	BGa-V.2-1	Reproduction of plants.
		BGa-V.2-2	Male and female reproductive systems.
		BGa-V.2-3	Menstrual cycle, pregnancy and contraception.
		BGa-V.2-4	Gene and inheritance.
		BGa-V.2-5	Inheritance of human.
		BGa-V.2-6	Inquiry activity: DNA extraction.
	Evolution (Gb)	BGb-V.2-1	Evolution.
	Biodiversity (Gc)	BGc-V.2-1	Biodiversity.
		BGc-V.2-2	Classification of organisms.
		BGc-V.2-3	Inquiry activity: to observe the biodiversity in schoolyards.
Organisms and the environment (L)	Interaction between organisms (La)	BLa-V.2-1	Interaction between organisms.
	Interaction between organisms and the environment (Lb)	BLb-V.2-1	Inquiry activity: ecosystem construction and observation.
		BLb-V.2-2	Ecosystem.
Science, technology, society, and humanities (M)	Relationship between science, technology and society (Ma)	BMa-V.2-1	Biotechnology and its applications.
		BMa-V.2-2	Recognize genetic engineering.
	History of science development (Mb)	BMb-V.2-1	Mendel's genetic law.
Resources and	Development and	BNc-V.2-1	Development and utilization of energy.

Topics	Subtopics	Learning Content
sustainable development (N)	utilization of energy (Nc)	

VI. Implementation Directions

1. Curriculum Development

(1) Principles of curriculum design:

A. The curriculum design of natural sciences in vocational senior high schools should be articulated with national elementary and junior high schools as well as fundamental courses of universities.

B. The curriculum design of natural sciences in vocational senior high schools should emphasize practical and hands-on learning according to the nature of the subject.

C. For the curriculum of natural sciences in vocational senior high schools, select and use textbook version with principles as follows:

(a) The groups using Version B curriculum guidelines should not be changed. However, if relevant professional subjects for chemistry engineering group are added as a result of school curriculum development, teachers may choose between Chemistry Version A or B.

(b) Physics Version B is a 4-credit course. However, to meet fundamental theoretical needs of various industrial engineering groups, schools should offer a 2-credit course to the school-developed curriculum in response to students' needs for studying professional courses.

(c) When the MOE-mandated natural sciences subjects are insufficient to meet students' learning needs, it is recommended that school-required subjects should be established as a supplement.

D. The curriculum design of natural sciences in vocational senior high schools should appropriately integrate various issues into relevant courses for students to think about these issues in different subject contexts and to achieve mutual inspiration and integration.

(2) Mechanisms of curriculum integration:

A. The curriculum development of each domain in vocational senior high schools should establish a mechanism to review and have dialogue among subjects and disciplines within the domain of natural sciences. This is to implement mutual integration of curriculum content between subjects and disciplines within a domain curriculum guidelines.

B. The curriculum design of each subject of natural sciences in vocational senior high schools should be flexible and autonomous. In addition, it should consider the integration of related subjects to diversify the curriculum design and to complement and support teaching materials of each subject.

(3) School courses operations:

A. To highlight the regional characteristics of vocational senior high schools, each school may offer elective courses related to local natural environment, lifestyle, industrial and business activities, and social development based on regional features.

B. Each school should select subjects based on the needs of vocational groups/subjects and establish elective courses in response to students' needs for studying professional subjects.

C. To facilitate school courses operation and elective course planning, each school may integrate and adjust the overall use of computer classrooms, laboratories, and some vocational classrooms depending on the availability of classroom space, equipment, and facilities

2. Teaching Material Selection and Composition

(1) Content of teaching materials:

A. The content of teaching materials for each subject of natural sciences in vocational senior high schools should emphasize interrelationship and applications so students may develop the ability to integrate knowledge.

B. The content of teaching materials for each subject of natural sciences in vocational senior high schools should integrate students' life experiences and make use of online resources. This is to increase students' interest in learning and applicability of their knowledge, as well as to broaden their worldview.

C. The content of teaching materials for each subject of natural sciences in vocational senior high schools should appropriately integrate materials of various issues.

(2) Principles of teaching material selection:

(1) The selection and composition of teaching materials for each subject of natural sciences in vocational senior high schools should emphasize the establishment of basic concepts and acquisition of principles. Instead of giving fragmented and non-systematic knowledge materials, schools should provide learning materials with high-level cognitive thinking for students to learn to solve problems with scientific knowledge, develop a scientific attitude, and understand nature of science.

(2) The selection and composition of teaching materials for each subject of natural sciences in vocational senior high schools should be based on student characteristics, learning needs, regional characteristics of each school, and learning performance at each educational stage. Schools should develop their own curriculum, select appropriate textbooks, or select and compose teaching materials needed for alternative learning hours/courses. However, the self-composed teaching material used throughout school semester or school year should be submitted to the Committee of School Curriculum Development of each school for review.

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

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

3. Teaching Implementation

(1) Teachers' instructional design should conform to curriculum objectives and consider student differences. For faster or slower learners, teachers should implement extension or remedial instruction respectively.

(2) When teaching a new unit, teachers should provide more examples that are based on students' daily life experiences and existing knowledge or experience to enhance their learning motivation. Furthermore, to achieve the curriculum objective, which is acquiring new knowledge or concepts, teachers should guide students to identify problems, reason, analyze, use inductive and deductive reasoning, and interpret during problem-solving.

(3) When instructing, teachers should prioritize teaching students the application of scientific methods and the cultivation of scientific attitudes instead of focusing solely on imparting knowledge. Students should be able to understand the nature of science, develop habits of applying scientific thinking and inquiry, and enhance their thinking intelligence to improve their problem-solving skills.

(4) Teachers should actively encourage students to question and discuss together in class to create a lively and interesting teaching atmosphere. In addition, teachers may separate students into groups during discussions to promote cooperation and mutual learning among students. Lastly, teachers should use various types of instructional media and information technology device to enhance the effectiveness of classroom instruction.

(5) Teachers should focus on the integration and application of scientific concepts while teaching.

(6) Teachers should offer education according to students' aptitudes without any discrimination. Moreover, teachers should use the art of teaching and counseling skills to fully keep track of the learning status of each student, stimulate their potential, and aim to enhance each student's natural science competency.

(7) Teachers should conduct self-assessment after lessons and refer to students' learning outcomes assessments to gradually revise and improve their instructional design and enhance their teaching.

(8) Teachers should teach science experiments and activities in continuous sessions. Students should understand the purpose of experiments and know how to control and manipulate variables. During experiments, teachers also should guide students to develop the scientific

attitude, which include mutual cooperation, respect for others' opinions, being truthful to data, and seeking truth from facts.

4. Teaching Resources

(1) Schools should procure laboratory equipment according to basic standards for equipment required for classes and instructional needs.

(2) The aim of equipment used for each subject in this domain is to meet instructional needs and enable students to fully understand curriculum content, and to improve learning outcomes. In addition, teachers should also make use of electronic teaching equipment and social resources to support their teaching.

(3) Ventilation, safety and environmental pollution prevention measures should be considered in laboratories and experiment activities. The equipment damaged during experiment should be repaired or resupplied as soon as possible.

(4) Schools should encourage teachers to create their teaching materials and aids or have them collectively created by the Teaching and Research Committee, and further promote them to share their teaching experiences. In addition, each school should make use of audio-visual teaching materials created and developed by relevant organizations.

(5) Schools should give textbooks for each teacher. Moreover, schools should also purchase more reference books, scientific journals, and magazines for teachers and students to borrow for reference to teaching research or study.

(6) Each school may set up specimen rooms, ecological ponds, nurseries, and other teaching areas according to curriculum needs and school conditions.

(7) Schools may make or purchase specimens, models and wall charts according to instructional needs, and the contents along with number can be determined according to needs.

5. Learning Assessment

(1) Assessment design and implementation:

A. Teachers should include placement assessment, formative assessment, diagnostic assessment, and summative assessment while teaching.

B. The assessment design should strengthen the dimension of inquiry skills to cultivate students’ thinking intelligence and problem-solving skills.

C. Learning assessment should take into account of the aspects of cognition, affection, and skill.

D. Teachers should adopt appropriate and diverse assessment methods for learning assessment with reference to curriculum objectives, core competencies, learning performance, learning content, and differences among individual students.

E. The assessment schedule can be divided into daily and regular assessments. Teachers should implement assessments using multiple methods including written tests, assignments, experiments, reports, information collection and organization, and daily learning performance.

(2) Assessment analysis and review:

A. Teachers should analyze and make use of assessment results as the basis of improving teaching materials and learning guidance, as well as for implementing remedial teaching.

B. Teachers should regularly examine and improve assessment tools to enhance the effectiveness of learning assessment.