Chinese Taipei

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Introduction

Overview of Education System

The administration of education in Taiwan is carried out in a unified, two-tiered system that includes the Ministry of Education at the central level and bureaus of education at the local level. Depending on the administrative division, the functions and authority of the government organizations are different. Before the 1990s, the central government set education policy at the local level. Since then, to adapt to social changes, education reforms have led to an increase in the authority of local governments over education policy.[1,2]

Formal education from preprimary school to university includes nine years of compulsory education (Grades 1 to 9). The total time that students spend in formal education varies but normally includes two years of preprimary school, six years of primary school, three years of junior high school, three years of senior high school or senior vocational school, and four to seven years of college or university. However, about 7% of students choose to go to five years of senior vocational school and then to a two-year senior college. After college or university, advanced education programs leading to a master's degree (one to four years) or a doctoral degree (two to seven years) are optional. At all levels of formal education, special education programs are available to students with physical or mental disabilities. The curriculum of all subjects for Grades 1 to 9 (primary school and junior high school) were regulated by the Grade 1 to 9 Curriculum Guidelines until the end of June 2019. The new Curriculum Guidelines of 12-Year Basic Education were officially implemented in September 2019.

Use and Impact of TIMSS

Taiwan has participated in TIMSS since 1999. TIMSS has played a role in the discussion of curriculum reform, evaluating the efficacy of mathematics and science education, and monitoring the education issues in Taiwan. Moreover, the performance of Taiwanese students in the next two cycles of TIMSS studies will provide important feedback to the Ministry of Education to evaluate the effectiveness of the new curriculum.

The results of TIMSS 2007 validated the efficacy of the reform of curriculum guidelines for Grades 1 to 9 in terms of student outstanding achievement.[3] Yet despite this high achievement, the results of TIMSS 2011 have raised in-depth issues including students' low interest and confidence in science and mathematics, the high percentage of students with achievement below the intermediate benchmark, the growing urban-rural disparity in achievement, less engaging teaching in eighth grade mathematics and science lessons, and the low percentage of junior high school students with teachers emphasizing scientific inquiry. These issues have not only drawn the attention of educators and policymakers but also motivated the revision of the curriculum for Grades 1 to 9. In response to these issues, the National Science Council and the Ministry of Education continue to call for proposals and to sponsor relevant research projects.[4] Since 2001, the National Science Council has focused on providing extra support to disadvantaged students in mathematics, and enhancing the interest and self-confidence of all students in learning mathematics and science. A special call for proposals in 2006 reflects that significant efforts have been undertaken to address these issues. The Ministry of Education also has sponsored projects to enhance students' interest (e.g., Just Do Math Project[5]) and strengthen scientific inquiry skills (e.g., Project for Promoting Elementary and Junior-High School Science Teachers' Ability of Designing and Implementing Inquiry-based Curriculum[6]). The Ministry of Education continues to provide training and resources to teachers to address these issues. For example, the Ministry of Education has formed central consultation group for mathematics and science to organize workshops and present teaching demonstration.[7] In addition, to build prime indicators for the efficacy of education policy and the foundation of promoting evidence-based policy, the Taiwan International Large-Scale Study Center (TILSSC) has been funded since 2016 to coordinate and utilize the results of TIMSS, the Programme for International Student Assessment (PISA), and other international studies.[8]

The Mathematics Curriculum in Primary and Lower Secondary Grades

The Grade 1 to 9 Curriculum Guidelines[9] encompass seven major learning areas: Language Arts, Health and Physical Education, Social Studies, Arts and Humanities, Mathematics, Science and Technology, and Integrative Activities. The goals of these guidelines include the following:

- Develop the ability to work with algorithms, use abstract reasoning, make inferences, and communicate understanding
- Develop problem solving skills
- Develop basic skills as a foundation for learning advanced mathematics
- Develop an appreciation of the beauty of mathematics

The Grade 1–9 Mathematics Curriculum Guidelines specify five mathematics strands, implemented according to grade level: Number and Quantity, Geometry, Algebra, Statistics and Probability, and Mathematical Connections. The curriculum guidelines provide corresponding indicators of competence, based on student cognitive development and the relationships within a

strand and across strands in Grades 1 to 9.[10] The objectives of the five strands are outlined briefly as follows:

- Number and Quantity—In elementary schools, students are expected to master arithmetic operations with natural numbers; to understand the concepts of time, distance, area, weight, volume, capacity, and angles, and the units used to measure them; to understand that fractions and decimals may refer to parts of a set or parts of a whole; and to use estimation strategies in computation, problem solving, and checking computations. The junior high school curriculum includes negatives, arithmetic operations with integers and rational numbers, absolute value, prime and composite numbers, and arithmetic and geometric sequences.
- Geometry—In Grades 1 to 3, students learn to identify, explore, and manipulate geometric figures. In Grades 4 to 5, students are expected to express numerical relationships in and among geometric figures. In Grades 6 to 7, students develop spatial and visual reasoning. In Grades 8 to 9, students study plane geometry as an introduction to the concept of mathematical proof and learn to appreciate it for its intrinsic value.
- Algebra—Students learn to solve problems using symbolic representations. In elementary school, students learn to express relationships in equations or sentences, evaluate algebraic expressions, and solve simple linear equations. In junior high school, students learn to use equations or inequalities to represent the relationships among the quantities described in questions, solve linear equations and inequalities with one variable and simultaneous linear equations with two unknowns, factor polynomials, solve quadratic equations, and represent linear and quadratic functions in graphs.
- Statistics and Probability—This strand has strong connections to Algebra as well as to Number and Quantity. Students are introduced to the concept of probability, interpretation of data, and problem solving with statistics. In elementary school, students mastering this academic content will be able to create and interpret simple statistical tables and pie charts. In Grade 9, students learn the concepts of frequency, mean, median, and mode. They also learn how to use computers and software to calculate with statistics and make tables and graphs.
- Mathematical Connections—To encourage meaningful learning, this strand emphasizes integration among the other four strands and the transfer of mathematical knowledge and reasoning from school to daily life, as well as to other subjects, such as science and technology.

The Science Curriculum in Primary and Lower Secondary Grades

The goal of the science curriculum is to increase science literacy. Science literacy encompasses eight domains: Knowledge of Science and Technology, Science Processing Skills, Development of Processing Intelligence, Scientific Applications, Designing and Producing, Understanding the Nature of Science, Understanding the Development of Science and Technology, and Development of Scientific Attitudes. The science and technology curriculum for Grades 1 to 9 consists of four

stages: Stage 1 (Grades 1 to 2), Stage 2 (Grades 3 to 4), Stage 3 (Grades 5 to 6), and Stage 4 (Grades 7 to 9). The competence indicators for students in the four stages are listed separately in the Grades 1 to 9 Science and Technology Curriculum Guidelines.[11] The objectives of science learning in the eight domains are as follows:

- Knowledge of Science and Technology—Five themes comprise this domain: the composition of nature and its features, actions of nature, evolution and continuity, life and environment, and sustainable development. Each theme has several topics (e.g., actions of nature includes three topics: changes and equilibrium, structure and function, and interaction). Each topic consists of several subtopics (e.g., structure and function includes the structures and functions of plants and animals).
- Science Processing Skills—Science processing skills are the executive skills of conducting scientific inquiry. In addition to problem definition and evaluation (described in the processing intelligence domain), science processing skills include observation (recognizing meaningful variables and measuring them quantitatively), comparison and classification (defining and controlling variables), organization and connection (using evidence to establish causal relationships), induction and inference (explaining data), and communication (acquiring information, developing clear and scientific statements, and expressing oneself appropriately).
- Development of Processing Intelligence—Processing intelligence refers to the scientific thinking used to define, develop, and evaluate problems. It comprises comprehensive thinking (forming integrated points of view from evidence), inferential thinking (making predictions based on scientific rules and theories), creative thinking (finding solutions from different perspectives, facing challenges flexibly, and acting with reflection), critical thinking (comparing reality to ideal or theoretical conditions and reasoning about the comparison), and problem solving (planning and evaluating solution methods and strategies).
- Scientific Applications—Scientific applications refer to the use of scientific methods and knowledge learned in the classroom to solve daily life problems. Scientific methods involve the operation of machines and use of instruments, the planning of inquiry activities, and the decision making process, etc. This domain emphasizes the transfer of problem solving strategies from school to daily life.
- Designing and Producing—Designing refers to identifying people's needs and conceiving a way to satisfy those needs. Producing refers to using technical and practical knowledge to choose appropriate tools and materials to create products that satisfy an identified need.
- Understanding the Nature of Science—This domain refers to the properties of scientific knowledge and research activities. Students are expected to reflect on their science learning experiences, recognize the existence of natural laws, and master scientific argumentation. Scientific argumentation requires students to differentiate evidence from theory, consider the internal consistency of explanations, and construct relationships between evidence and theories.

- Understanding the Development of Science and Technology—The development of science and technology concerns the creation and change of technology and the relationship among science, technology, and society. This domain has three facets: the nature of technology (recognizing the importance and characteristics of technology and the relationship between science and technology), the evolution and advancement of technology (through the agricultural, industrial, and information eras and trends of technology development), and technology and society (making sense of the ways technology interacts with our lives, including individual career planning and the interaction between the development of industry and technology).
- Development of Scientific Attitudes—This domain covers four learning stages: The Joy of Carrying Out Explorations (Stage 1, Grades 1 to 2), The Joy of Discovery (Stage 2, Grades 3 to 4), Being Careful and Tangible (Stage 3, Grades 5 to 6), and Being Precise and Realistic (Stage 4, Grades 7 to 9).

Professional Development Requirements and Programs

Elementary and secondary school teachers were required to complete a minimum of 90 hours of professional development every five years prior to 2003. However, these regulations were abolished in 2003, and local bureaus of education now regulate teacher professional development programs. According to the Guideline of Professional Standard for Teachers,[12] the local bureaus of education, schools, and the institutions that provide teacher education programs can plan and arrange workshops for professional development, and teachers are encouraged to participate the workshops and the communities for professional development.

Monitoring Student Progress in Mathematics and Science

Under education reform, the Joint Public Senior High School Entrance Examination was replaced in 2001 with the Basic Competency Test, which was administered twice a year and provided the main selection criteria for senior high schools.[13] The Basic Competency Test covered Chinese, English, mathematics, natural science, and social science, and emphasized students' fundamental knowledge and skills. In 2014, the Comprehensive Assessment Program for junior high students was implemented to replace the Basic Competency Test.[14] The main differences between the two tests include the following: the Basic Competency Test is a norm-referenced test, while the Comprehensive Assessment is a standards-referenced test; in addition to multiple-choice items, the Comprehensive Assessment includes constructed response and short essay items, and the Comprehensive Assessment is optional for students applying to senior high school. The long-term objective of the central government is to use the results of the Comprehensive Assessment for quality control of primary and lower secondary education rather than to provide the results for students to enter senior high schools.

In addition to the Basic Competency Test and the Comprehensive Assessment, various international studies in education (e.g., TIMSS and PISA) as well as nationwide and local assessments, such as the Taiwan Assessment of Student Achievement (TASA),[15] the Longitudinal Study of Achievement Growth in the Mathematics Literacy of New-Immigrant Children,[16] and Taiwan Assessment of Student Achievement: Longitudinal Study (TASAL),[17] have been conducted to monitor trends in student progress in mathematics and science at the population or individual level.

Special Initiatives in Mathematics and Science Education

The Ministry of Education and National Science Council convened the First National Congress on Science Education from December 20 to 21, 2002. The congress committee was composed of experts in mathematics and science education. Based on committee consensus, the ministry published the White Paper on Science Education, aiming to improve science education and related policies in Taiwan.[18] Education reform since 2002, including policies on teacher education and the General Guidelines of the Grades 1 to 9 Curriculum of Elementary and Junior High School Education, has had a major impact on science and mathematics education in Taiwan in the last decade.

A dramatically decreasing birth rate and changing economic structure in Taiwan has caused a new wave of education reform. The Twelve Year National Education Program aims to cultivate students' science and mathematics literacies through revisions to the curriculum for Grades 1 to 9. Echoing the Twelve Year National Education Program, the local education bureaus are building demonstrating centers for students to explore careers related to science, technology, and other fields.[19] To create an adaptive learning environment for the Twelve Year National Education, the Ministry of Education has provided special education programs for both students with disabilities and gifted students.[20] To reduce the achievement gap, the Project for Implementation of Remedial Instruction is now provided for not only disadvantaged students, but any student with low achievement in mathematics.[21]

Although the Twelve Year National Education has many merits, its curriculum framework brings challenges to teachers. The curriculum framework for Grades 1 to 12 includes policies such as reducing the credit hours of compulsory science and mathematics courses, requiring teachers to implement activities of scientific inquiry, and expecting junior-high school students to apply calculators and computers to solve mathematics problems. These new policies have brought challenges to the education system in Taiwan, affecting both preservice and in-service teacher education and techniques of education evaluation.

Suggested Readings

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