Engineering THAILAND

Appendix 3: Comparison of curricula in STEM across a range of countries.

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Contents

1 Introduction and context

The curriculum comparison component of the project was reduced to a 'key points' comparison following a change in emphasis of the project. Thus a key points comparison was made between the Thai Year 6 - 12 curriculum for science, mathematics, Design and Technology and Information Technology with the Singapore lower secondary curriculum for Science and Mathematics; the USA New Generation Science Standards (NGSS); the Computing and Design and Technology Key Stage 3 programmes of study for England (lower secondary curricula); and the GCSE and A level Specifications (AQA Examination board) for Biology, Chemistry, Physics, Mathematics, Design and Technology, ICT and Computer Science.

The Singapore lower secondary curricula for Science and Mathematics were chosen because Singapore is a high performing country in TIMSS and PISA and the lower secondary phase is the crucial phase leading to these international benchmarking assessments.

The 'Computing' and 'Design and Technology' Key Stage 3 (Lower Secondary) programmes of study (curricula) for England were chosen for comparison against the Thai Year 6 - 9 Design and Technology and Information Technology curricula because they have only just been developed and implemented following extensive International comparison studies with curricula and practices across the World.

The GCSE and A level Specifications were chosen as these are the examination specifications used for entrance to all universities in the UK, including leading universities, such as Oxford and Cambridge. Examination specifications based on these are also used in Singapore, as many Singaporean secondary school students seek to enter UK universities.

There is significant commonality in the subject content of the Thai curricula and those against which they were compared. However, there are areas of difference. The comparison identified the following significant key areas of difference:

- Education and pedagogical philosophy.
- Skills and Processes (in Science only).
- Application (in Science only).
- Big ideas (in Science only).
- Introducing concepts at earlier ages (in Science only).
- Additional content and more depth.

These are described in more detail in the pages that follow.

Coverall conclusions

The comparison found that the Thai curricula for Science, Mathematics, Design and Technology and Information and Communication Technology have much in common with the syllabi and specifications against which they compared. The key areas of difference identified included education and pedagogical philosophy; skills and processes; application; 'Big ideas'; introducing concepts at earlier ages; additional content and more depth to the content of the curriculum. These areas could be addressed and embraced by the gifted teachers when they are reviewing, developing and planning their teaching and learning programmes; and when they are reviewing the additional units they teach to enhance the curriculum, developed in partnership with academics from local universities.

2: Science

Education and pedagogical philosophy

Singapore

General points

The Singapore Lower Secondary Science syllabus emphasises the need for a balance between the acquisition of science knowledge, skills and attitudes. In addition, as and when the topics lend themselves, the technological applications, social implications and the value aspects of science are also considered. It also emphasises the broad coverage of fundamental concepts in the natural and physical world.

Central to the curriculum framework is the inculcation of the spirit of scientific inquiry, with the conduct of inquiry founded on three integral domains of (a) Knowledge, Understanding and Application, (b) Skills and Processes and (c) Ethics and Attitudes. Within the curriculum these domains are identified as essential to the practice of science. The curriculum design seeks to enable students to view the pursuit of science as meaningful and useful. Inquiry is thus grounded in knowledge, issues and questions that relate to the roles played by science in daily life, society and the environment.

The science curriculum seeks to nurture the student as an inquirer. The teacher is the leader of inquiry in the science classroom. The following shows the description of each domain which frames the practice of science and the forms the structure of the curriculum:

Knowledge, Understanding and Application of:

- Scientific phenomena, facts, concepts and principles
- Scientific vocabulary, terminology and conventions
- Scientific instruments and apparatus including techniques and aspects of safety
- Scientific and technological applications

Skills and Processes

Skills	Processes
• Using apparatus and equipment • Posing questions • Observing • Classifying • Comparing • Communicating • Inferring • Formulating hypothesis • Predicting • Analysing • Elaborating • Verifying • Generating possibilities • Defining the problem	• Planning investigation • Creative problem solving

It is expected that in science teaching and learning, effort should initially be directed at teaching explicitly each of the skills through the use of appropriate activities. Later effort should be directed to helping students integrate some or all of the skills in scientific inquiry and creative problem solving.

Ethics and Attitudes

Ethics and attitudes
• Curiosity • Creativity • Objectivity • Integrity • Open-mindedness • Perseverance • Responsibility

The three domains run through all six themes of the curriculum. Thus each theme topic includes statements referring to Knowledge, understanding and application; Skills and processes and Ethics and attitudes. The core component includes the knowledge, skills and attitudes that all students should acquire.

The curriculum is organised by themes to help students appreciate the big ideas in science.

A brief description and key inquiry questions for each theme are given with suggested strategies and activities for inquiry. The curriculum is organised into the following six themes: Science & Technology; Measurement; Diversity; Models and Systems; Energy; and Interactions.

The Scientific Inquiry approach is used to weave the knowledge, skills, and attitudes in science throughout the 6 themes. In addition, the applications and impact of science and technology are included wherever appropriate.

There is also 15% freed up curriculum time, known as the white space, to enable teachers to use more engaging teaching and learning approaches, and/or to implement customised school-based programmes as long as the aims of the syllabus are met. This enables teachers to make learning more meaningful and enjoyable for their students.

Summary

- The Singaporean science curriculum seeks to nurture the student as an inquirer.
- A brief description and key inquiry questions are provided for each theme.
- Suggested strategies and activities for inquiry are also provided.
- Ethics and attitudes are integrated into all themes.

New Generation Science Standards (USA)

In NGSS Engineering is integrated into the standards both within the practices and core ideas.

'Science and Engineering Practices' is composed of 8 standards:

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Developing and using models
- Constructing explanations and designing solutions
- Engaging in argument from evidence

- Using mathematics and computational thinking
- Obtaining, evaluating and communicating

One of the four disciplinary core ideas is 'Engineering, Technology, and Applications of Science' and is composed of two standards:

Engineering Design	Links Among Engineering, technology, Science and Society
• Defining and Delimiting an Engineering Problem • Developing Possible Solutions • Optimizing the Design Solution	• Interdependence of Science, Engineering, and Technology • Influence of Engineering, technology, and Science on Society and the Natural World

English GCSE Biology, Chemistry and Physics Specifications

'How Science Works' underpins and flows through the GCSE Science Specifications in England, and is an assessed component of the specification. 'How Science Works' includes the following components:

- The thinking behind the doing. Science attempts to explain the world in which we live.
- Fundamental ideas. Evidence must be approached with a critical eye.
- Observation as a stimulus to investigation. Observation is the link between the real world and scientific ideas.
- Designing an investigation. An investigation is an attempt to determine whether or not there is a relationship between variables
- Making measurements. When making measurements we must consider such issues as inherent variation due to variables that have not been controlled, human error and the characteristics of the instruments used.
- Presenting data. To explain the relationship between two or more variables, data may be presented in such a way as to make the patterns more evident.
- Using data to draw conclusions. The patterns and relationships observed in data represent the behaviour of the variables in an investigation.
- Evaluation. In evaluating a whole investigation the repeatability, reproducibility and validity of the data obtained must be considered.
- Societal aspects of scientific evidence. A judgment or decision relating to social-scientific issues may not be based on evidence alone, as other societal factors may be relevant.
- Limitations of scientific evidence. Science can help us in many ways but it cannot supply all the answers.

Thus inquiry-based learning; the scientific inquiry, creative problem solving, and engineering processes; applications of science technology and engineering; and ethics and attitudes of science are integral philosophies underpinning the curricula. Although scientific investigation is a strand of the Thai Science curriculum it is not as explicitly integrated into the other strands of the curriculum.

The other components listed above are absent from the indicator and content specifications of the Thai Science curriculum.

2.1: Skills and processes

In the Singaporean curriculum skills and processes are integrated into all themes. It must also be noted that the processes include creative problem solving which is central to the implementation of STEM, and a process not included in the Thai Science curriculum.

It has also been emphasised in section X.1.1.2 that in the NGSS both Science and Engineering practices are included (Scientific inquiry and Engineering Design Process). The Science and Engineering practices are developed as holistic processes that reflect the Nature of Science and Engineering and the practices are integrated into the Core Ideas through the disciplinary idea 'Engineering, Technology, and Applications of Science'.

Also in the English GCSE Science Syllabi the skills and processes of science within the How Science Works component flow through the content components of the specifications, thus integrating the processes and skills into the curriculum.

As already raised. the processes are less explicitly integrated into the Thai Science content strands (strands 1 - 7) and the problem solving and engineering processes are absent.

There is also a possibility that in Strand 8 scientific inquiry may be too atomised and that the process skills maybe taught independently and not within the whole scientific inquiry process.

2.2: Application

In the Singaporean curriculum in addition to knowledge and understanding, Scientific and technological applications and implications is a domain that is included in all themes. It is thus integrated where appropriate into all themes.

In the NGSS Contemporary STEM contexts are integrated into the standards and Engineering, Technology and Applications of Science is a core idea, that includes 'Engineering Design' and 'Links Among Engineering, Technology, Science and Society'.

The applications and implications of science are integrated into the English GCSE and A level Syllabi, particularly contemporary developments in science and technology.

There are few applications referred to in the Thai Science curriculum indicator and core content specifications.

2.3: Big Ideas

In Singapore the curriculum is organised by themes (please refer to X.1.2.1) to help students appreciate the big ideas in science. Also the key inquiry questions and suggested strategies and activities for inquiry are designed to help develop the 'Big Ideas'.

In NGSS the core ideas focus on big ideas in science, these include:

- Matter and Its Interactions
- Motion and Stability: Forces and Interactions
- Energy
- Waves and Their Applications in Technologies for Information Transfer
- From Molecules to Organisms
- Ecosystems: Interactions, Energy, and Dynamics
- Heredity: Inheritance and Variation of Traits
- Biological Evolution: Unity and Diversity
- Earth’s Place in the Universe

- Earth’s Systems
- Earth and human activity

The Cross cutting concepts encourage the further development of the understanding of the big ideas of science, enabling students to understand the full picture.

The organisation of the Thai Science curriculum does not easily facilitate the development of big ideas during the key learning phases (Lower Secondary or Upper Secondary).

2.4: Introducing concepts at earlier stages

In the Singaporean curriculum the following topics are covered at Primary level whereas in the Thai Science curriculum they are covered in the lower secondary curriculum:

- human and animal systems
- plant systems
- animal and plant nutrition
- classifying substances
- electricity and magnetism
- electrical circuits
- forces
- velocity, speed, and acceleration

This enables students to start to develop their conceptual understanding of the key topics at an earlier stage and reduces the pressure on the curriculum content at lower secondary level.

2.5: Additional content and more depth.

When comparing the Thai Science curriculum for Years 10 - 12 with the English GCSE and A/S and A level Specifications it was found that

1. The Biology GCSE specification goes into greater depth on:

- Bioenergetics

2. The Chemistry GCSE specification goes into greater depth on:

- Chemical changes
- Energy changes
- Chemical analysis
- Chemistry of the atmosphere
- Using resources

3. The Biology A level specification goes into greater depth on:

- Cells and Stem Cells
- Exchange of substances with the environment
- Genetic information, variation and relationships in organisms
- Energy transfers in and between organisms
- The control of gene expressions

4, The A level Physics specification goes into greater depth on:

- Fields and their consequences
- Nuclear physics

- Astrophysics
- Medical physics
- Engineering physics
- Turning points in physics
- Electronics

5. The A level Chemistry specification goes into greater depth on, for example:

- Energetics
- Kinetics
- Thermodynamics
- Equilibrium
- Radox reactions
- Group 2 and Group 7
- Nuclear magnetic resonance spectroscopy

PLEASE NOTE: Normally when carrying out such a comparison we would consult with an in-country expert with greater knowledge and understanding of the curriculum. This was not possible on this project. This comparison was made by the individual team member interpreting the core content and indicators specified in the curriculum and comparing against the English syllabi. In practice teachers may go into greater depth than is suggested in the Thai Science curriculum indicator and core content specifications.

3: Mathematics

3.1:Education and pedagogical philosophy

Singapore

The Singapore lower secondary mathematics syllabus reflects the recent developments in mathematics education. The focus of the syllabus, as is the ultimate goal of the Thai Mathematics curriculum, is mathematical problem solving. The emphasis of the syllabus is on the development of concepts, skills and its underlying processes. This, together with the incorporation of thinking skills and the integration of IT in mathematics teaching and learning, supports the development of mathematical problem solving.

The primary aim of the mathematics programme is to enable pupils to develop their ability in mathematical problem solving, thus very similar to the Thai Mathematics curriculum. However the Singapore curriculum goes further - mathematical problem solving includes using and applying mathematics in practical tasks, in real life problems and within mathematics itself. In this context, a problem covers a wide range of situations from routine mathematical problems to problems in unfamiliar context and open-ended investigations that make use of the relevant mathematics and thinking processes. The attainment of this mathematical problem solving ability is dependent on five inter-related components - Concepts, Skills, Processes, Attitudes and Metacognition.

The Singapore Mathematics syllabus for lower secondary has specifications for three groups Special/Express, Normal Academic and Normal Technical. This comparison focussed on Special/ Express as this is the target group for the gifted programme.

3.2 Additional Content and more depth

Singapore

The Thai Mathematics curriculum and Singapore Special/Express Mathematics Syllabus are very similar. There are only a few areas covered in the Singapore Syllabus that are not covered in Thai Mathematics curriculum, these include:

For 'Numbers and operations' the Singapore curriculum also included

- Use of a scientific calculator
- Percentage
- Simple financial transactions

For 'Trigonometry' the Singaporean curriculum also included the ratios:

- sine
- cosine
- tangent

England

GCSE Mathematics Specification

The Thai Mathematics curriculum for Years 9 - 12 and the English GCSE Mathematics specification are quite similar in their content. There are no significant differences.

English A/S and A level Specification

In comparing the Thai Mathematics curriculum for Years 9 - 12 and the England A/S and A level specification there are some common strands at A/S level but particularly at A level there are a significantly large number of topics covered that are not covered in the Thai Mathematics curriculum. These are listed below.

Pure

- Coordinate Geometry
- Differentiation
- Integration
- Vectors
- Roots and Coefficients of a quadratic equation
- Calculus
- Matrices and Transformations
- Roots of Polynomials
- De Moivre's Theorem
- Proof by Induction
- Finite Series
- The Calculus of Inverse Trigonometrical Functions
- Hyperbolic Functions
- Arc Length and Area of surface of revolution about the x-axis
- Series and Limits
- Polar Coordinates
- Differential Equations
- Differential Equations – First Order
- Differential Equations – Second Order
- Vectors and Three-Dimensional Coordinate Geometry
- Matrix Algebra
- Solution of Linear Equations
- Determinants
- Linear Independence

Statistics

- Correlation and Regression
- Hypothesis Testing
- Chi-Square
- Contingency Table Tests

Mechanics

- Mathematical Modelling
- Kinematics
- Statics and Forces
- Momentum
- Newton's Laws of Motion
- Connected Particles
- Projectiles

- Moments
- Application of Differential Equations
- Uniform Circular Motion
- Work and Energy
- Vertical Circular Motion
- Relative Motion
- Dimensional Analysis
- Collisions in one dimension
- Collisions in two dimensions
- Further Projectiles
- Projectiles on Inclined Planes
- Frameworks
- Vector Product and Moments
- Centres of mass by Integration for Uniform Bodies
- Moments of Inertia
- Motion of a Rigid Body about a Fixed Axis
- Simple Harmonic Motion
- Forced and Damped Harmonic Motion
- Stability
- Variable Mass Problems
- Motion in a Plane using Polar Coordinates

Decision

- Simple Ideas of Algorithms
- Graphs and Networks
- Spanning Tree Problems
- Matchings
- Shortest Paths in Networks
- Route Inspection Problem
- Travelling Salesperson Problem
- Linear Programming
- Mathematical Modelling
- Critical Path Analysis
- Allocation
- Dynamic Programming
- Network Flows
- Linear Programming
- Game Theory for Zero Sum Games

PLEASE NOTE: Normally when carrying out such a comparison we would consult with an in-country expert with greater knowledge and understanding of the curriculum. This was not possible on this project. This comparison was made by the individual team member interpreting the core content and indicators specified in the curriculum and comparing against the English syllabi. In practice teachers may go into greater depth than is suggested in the Thai Science curriculum indicator and core content specifications.

Recommendations

We are aware that much of the Mechanics mathematics included in the A level Mathematics specification is covered in the Thai Science curriculum physics component. We would suggest that the gifted programme teachers compare their teaching programmes in physics with the Mechanics topics listed above and possibly build any missing topics into the physics programme

We are also aware that the gifted programme teachers are currently teaching additional mathematics units on their programme to enhance the Thai Mathematics curriculum. They could review these units and in consultation with local university academics and add content from the list above under the Pure, Statistics and Decisions headings

The gifted programme teachers for mathematics could also add the small topics that are covered by the Singapore Syllabus and not covered in the Thai Mathematics curriculum

The gifted programme teachers could also adopt the Singaporean philosophy of mathematical problem solving in a range of contexts, including unfamiliar contexts to enhance their teaching programmes.

4: Occupations and Technology: Design and Technology

4.1Education and pedagogical philosophy

English Key Stage 3 Programme of Study for Design and Technology

The Design and Technology programme of study shares much in common with the Thai Design and Technology strand. Design and Technology is considered an inspiring, rigorous and practical subject. Using creativity and imagination, students design and make products that solve real and relevant problems within a variety of contexts, considering their own and others' needs, wants and values. They acquire a broad range of subject knowledge and draw on disciplines such as mathematics, science, engineering, computing and art, thus adopting a STEM approach to the subject. Pupils learn how to take risks, becoming resourceful, innovative, enterprising and capable citizens. Through the evaluation of past and present design and technology, they develop a critical understanding of its impact on daily life and the wider world. High-quality design and technology education makes an essential contribution to the creativity, culture, wealth and well-being of the nation.

Aims

The programme of study for design and technology aims to ensure that all pupils:

- develop the creative, technical and practical expertise needed to perform everyday tasks confidently and to participate successfully in an increasingly technological world
- build and apply a repertoire of knowledge, understanding and skills in order to design and make high-quality prototypes and products for a wide range of users
- critique, evaluate and test their ideas and products and the work of others
- understand and apply the principles of nutrition and learn how to cook.

4.2 Additional Content and more depth

English Key Stage 3 Design and Technology programme of study

The Thai Design and Technology Curriculum for Years 7 - 9 and the English Key Stage 3 Design and Technology programme of study share an emphasis on the design and making processes. However the English programme of study does include additional components that are very important aspects of the process. These include

Design

- use research and exploration, such as the study of different cultures, to identify and understand user needs
- use a variety of approaches [for example, biomimicry and user-centred design], to generate creative ideas and avoid stereotypical responses

Evaluate

- analyse the work of past and present professionals and others to develop and broaden their understanding
- investigate new and emerging technologies
- test, evaluate and refine their ideas and products against a specification, taking into account the views of intended users and other interested groups

- understand developments in design and technology, its impact on individuals, society and the environment, and the responsibilities of designers, engineers and technologists

Technical knowledge

- understand and use the properties of materials and the performance of structural elements to achieve functioning solutions

The English Key Stage 3 programme of study in addition to the Thai curriculum also includes 'Cooking and nutrition', with the following philosophy and objectives:

As part of their work with food, pupils should be taught how to cook and apply the principles of nutrition and healthy eating. Instilling a love of cooking in pupils will also open a door to one of the great expressions of human creativity. Learning how to cook is a crucial life skill that enables pupils to feed themselves and others affordably and well, now and in later life.

Pupils should be taught to:

- understand and apply the principles of nutrition and health
- cook a repertoire of predominantly savoury dishes so that they are able to feed themselves and others a healthy and varied diet
- become competent in a range of cooking techniques [for example, selecting and preparing ingredients; using utensils and electrical equipment; applying heat in different ways; using awareness of taste, texture and smell to decide how to season dishes and combine ingredients; adapting and using their own recipes]
- understand the source, seasonality and characteristics of a broad range of ingredients.

English GCSE Specification Design and Technology

The GCSE specification has a great deal in common with the Thai Design and Technology Strand for Years 10 - 12, including the identification of appropriate technologies to solve a problem (including thinking about sustainability), designing and making a utensil, and evaluating the utensil. However the GCSE specification takes this further into the areas of market influence and manufacturing. Thus the specification has two units composed of the following:

Unit 1: Design and Market Influence

- Analysis of designs and products
- Creativity
- Quality assurance of product(s) through testing and evaluation
- Evaluation of own product
- Social, cultural, moral and environmental issues
- Packaging and labelling
- Safety for the consumer
- Processes and Manufacture
- Materials and components
- Systems and control
- Information and Communication Technology

Unit 2: Designing and making practice

- Investigating the design
- Development of design proposals (including modelling)

- Making
- Testing and Evaluation
- Communication

England AS and A level: Product Design (3-D Design)

Once again the AS and A level specification has the designing and making processes in common with the Thai curriculum, but goes into much greater depth and engagement with the full range of materials, components, design processes, customer safety, industrial workplace, health and safety and manufacturing processes. It is very much geared to preparing students for taking up careers in manufacturing and the manufacturing work place. The four units include:

Unit 1: Materials, Components and Applications (AS level)

- Materials and components
- Natural woods
- Man-made boards
- Laminates and veneers
- Ferrous metals
- Non-Ferrous metals
- Alloys
- Polymers
- Biodegradable polymers
- Elastomers
- Composites
- Compliant materials
- Smart materials
- Modern Materials
- Product components
- Adhesives
- Design and Market Influences
- Environmental/Sustainability Issues
- Ergonomics and anthropometrics
- Inclusive Design
- Consumer Safety
- Processes and Manufacture
- Fabrication methods: Woods, Metals, Plastics
- Forming methods: Woods, Metals, Plastics, Composites
- Redistribution methods: Metals, Cermets, Polymers
- Wasting processes
- CAM Processing
- Finishing materials and processes: Woods, Metals, Polymers
- Health and Safety
- Quality control

Unit 2: Learning Through Designing and Making (AS level)

- Investigation and Clarification of Problems
- Development of Design Proposal
- Making/Modelling
- Evaluation and Testing
- Communication and Presentation
- Unit 3: Design and Manufacture (A level)
- Materials and components
- Design and Market Influences
- Major developments in technology
- A study of manufactured products and systems
- Product life cycle
- The influence of design and technology in society
- Role of the designer
- The marketing function
- Design methods
- Design processes
- Safety
- Safety Legislation
- Communication methods
- Illustration, selection and use of appropriate 2D/3D techniques
- Enhancement
- Information drawing
- Modelling
- Use of ICT in Design
- Development
- Human needs
- Human factors
- Quality assurance and quality control
- The work of past and present designers
- Copyright protection
- Design methods
- The influence of design and technology in society
- Product development and improvement
- Communication methods - detail and form of products, environments and systems so that they can be manufactured
- Design in the human context
- Sustainability and Environmental concerns
- Processes and Manufacture
- ICT applications
- Manufacturing systems

- Product development and improvement
- Manufacturing systems
- Safety
- Systems and control

Unit 4: Learning Through Designing and Making (A level)

- Investigation and Clarification of Problems
- Development of Design Proposal
- Making/Modelling
- Evaluation and Testing
- Communication and Presentation

Recommendations

The gifted programme teachers of Design and Technology in Years 7 -9 when involved in the Design and make process could also build in further background research, the consideration of the properties of materials and evaluation of their utensils and others developed. This would also link more with the philosophies and processes encouraged in the STEM units and Engineering course developed by this project

The gifted programme teachers of Design and Technology in Years 10 - 12 could enhance their programmes by also introducing the Materials and components, Design and market influences and Processes and manufacture, including quality control and safety into their programmes. These components are included in the Engineering course developed by this project, thus they could be reinforced in the Design and Technology experience of the project.

5 Information and Communication Technology

5.1 Education and pedagogical philosophy

England Key Stage 3 Programme of Study for Computing

The Thai Information and Communication Technology curriculum and the England programme of study for computing share many philosophies and aims. However the Key Stage 3 programme of study has a greater emphasis on the role of computing in STEM and the development of thinking and creativity, in addition to knowledge and understanding to create programs, systems and a range of content. The philosophy of the England Key Stage 3 programme of study for computing is based on the following:

A high-quality computing education equips pupils to use computational thinking and creativity to understand and change the world. Computing has deep links with mathematics, science, and design and technology, and provides insights into both natural and artificial systems. The core of computing is computer science, in which pupils are taught the principles of information and computation, how digital systems work, and how to put this knowledge to use through programming. Building on this knowledge and understanding, pupils are equipped to use information technology to create programs, systems and a range of content. Computing also ensures that pupils become digitally literate – able to use, and express themselves and develop their ideas through, information and communication technology – at a level suitable for the future workplace and as active participants in a digital world.

Aims

The national curriculum for computing aims to ensure that all pupils:

- can understand and apply the fundamental principles and concepts of computer science, including abstraction, logic, algorithms and data representation
- can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve such problems
- can evaluate and apply information technology, including new or unfamiliar technologies, analytically to solve problems
- are responsible, competent, confident and creative users of information and communication technology.

5.2 Additional Content and more depth

England Key Stage 3 Computing programme of study

The England Key Stage 3 Computing Programme of Study in addition to aspects in common with the Thai Information and Communication Technology curriculum also includes:

- design, use and evaluate computational abstractions that model the state and behaviour of real-world problems and physical systems
- understand several key algorithms that reflect computational thinking [for example, ones for sorting and searching]; use logical reasoning to compare the utility of alternative algorithms for the same problem
- understand simple Boolean logic [for example, AND, OR and NOT] and some of its uses in circuits and programming; understand how numbers can be represented in binary, and be able to carry out simple operations on binary numbers [for example, binary addition, and conversion between binary and decimal]

- undertake creative projects that involve selecting, using, and combining multiple applications, preferably across a range of devices, to achieve challenging goals, including collecting and analysing data and meeting the needs of known users
- create, re-use, revise and re-purpose digital artefacts for a given audience, with attention to trustworthiness, design and usability

England GCSE ICT and Computer Science Specifications

The two GCSE specifications have great deal in common with the Thai Information and Communication Technology Strand for Years 10 - 12, including the development of understanding of the technologies, components and systems; the uses and applications in society; programming; and solving problems with ICT. However, the GCSE Computer Science Specification goes into greater depth and application with regard programming, this specification includes:

- Fundamentals of algorithms
- Programming
- Fundamentals of data representation
- Computer systems
- Fundamentals of computer networks
- Fundamentals of cyber security
- Ethical, legal, and environmental impacts of digital technology on wider society, including issues of privacy
- Aspects of software development

England AS and A level: Information and Communication Technology and Computer Science

The AS and A level Specification for ICT and Computer Science have much in common with the content of the Thai Year 10 - 12 ICT Strand, including a compulsory project, however, the A level specifications go into greater depth in the applications of ICT in business, commerce and industry and preparing the students for careers and working in the world of ICT, including:

- The Use of ICT in the Digital World
- Future developments
- Information and systems
- Managing ICT
- ICT strategy
- ICT policies
- Legislation and regulations
- Developing ICT solutions
- Development methods
- Techniques and tools for systems development
- Introducing large ICT systems into organisations
- Training and supporting users
- External and internal resources
- Computer Science

- Fundamentals of programming
- Fundamentals of data structures
- Fundamentals of algorithms
- Theory of computation
- Fundamentals of data representation
- Fundamentals of computer organisation and architecture
- Consequences of uses of computing
- Fundamentals of communication and networking
- Fundamentals of data bases
- Big data
- Fundamentals of functional programming
- Systematic approach to problem solving
- Computing practical project

Recommendations

Gifted programme teachers of ICT in Years 7 -9 could introduce more programming into their teaching programme

Gifted programme teachers of ICT in Years 10 - 12 could enhance the computer science experience of the students and further develop their understanding of the applications of ICT in business, commerce and industry.

Conclusions

The comparison found that the Thai curricula for Science, Mathematics, Design and Technology and Information and Communication Technology have much in common with the syllabi and specifications against which they compared. The key areas of difference identified included education and pedagogical philosophy; skills and processes; application; 'Big ideas'; introducing concepts at earlier ages; additional content and more depth to the content of the curriculum. These areas could be addressed and embraced by the gifted teachers when they are reviewing, developing and planning their teaching and learning programmes; and when they are reviewing the additional units they teach to enhance the curriculum, developed in partnership with academics from local universities.

8: Workshop Activity

During session 1 of the workshop following an introduction summarising the above points in their table groups the participants were asked to carry out the following tasks:

1. As an individual choose 5 bullet points from the slides that you think are most important to address in your school.
2. Put the five bullet points you have chosen in order of importance.
3. Score the most important 5, Second 4, Third 3, Fourth 2, and Fifth 1.
4. Put all your group scores onto a sheet of paper.
5, Calculate the total for each bullet.
6. Identify the top 5 scores and put them in order 1 to 5
7. As a group discuss how you could address each of the top 5 and put them into practice in your schools.
8. Prepare to present the outcomes of your discussions.

The participants identified the following areas (in order of popularity) that they could address in school:

- Application
- Big ideas
- Skills and processes
- Inquiry-based learning

Recommendations

- The gifted programme teachers could build applications of science into the curriculum when they are planning their teaching programmes. They could also teach in context, thus also enabling them to easily incorporate applications into the teaching and learning experiences.
- The gifted programme teachers could plan in science teams their teaching programmes to develop the 'Big Ideas' of science across the three subjects of Biology, Chemistry and Physics.
- In addition to incorporating/integrating scientific inquiry into their teaching programmes the gifted programme teachers could also incorporate the development of creative problem solving. This will also be achieved through the incorporation of the Engineering course and STEM units developed by this project.
- The engineering design process will also be incorporated through the adoption of the Engineering course developed by this project.
- When reviewing the additional units currently taught on the gifted programme and planning additional units to teach on the gifted programme the teachers could also look at the English A/S and A level specifications for the science subjects to extend the knowledge, understanding and skills developed by the current Science curriculum. This could be done in consultation with the academics from local universities with whom they have worked to develop the current additional units incorporated into their programmes.

8: Workshop presentation

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Curriculum comparison: Key Points

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Comparison

A comparison between the Thai Year 6 - 12 curriculum for science, mathematics and design and technology and Information Technology with

- Singapore lower secondary curriculum
- New Generation Science Standards
- Computing and Design and Technology Key Stage 3 programmes of study for England(lower secondary curricula)
- GCSE, AS and A2 Syllabi for Biology, Chemistry, Physics, Mathematics, Design and Technology and ICT

To identify **key points**

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Key points

- Education and pedagogical philosophy
- Skills and Processes
- Application
- Big ideas
- Introducing concepts at earlier ages
- Additional content and more depth

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Example: Science

Education and pedagogical philosophy

- The Singaporean science curriculum seeks to nurture the student as an inquirer
- A brief description and key inquiry questions are provided for each theme
- Suggested strategies and activities for inquiry are also provided
- Ethics and attitudes are integrated into all themes
- in NGSS STEM is integrated into the standards both within the practices and core ideas
- Working scientifically underpins the GCSE Science in England

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Skills and processes

- In the Singaporean curriculum Skills and processes are integrated into all themes
- processes include creative problem solving
- In NGSS Both Science and Engineering practices are included (Scientific inquiry and Engineering Design Process)
- The Science and Engineering practices are developed as holistic processes that reflect the Nature of Science and Engineering
- The practices are integrated into the Core Ideas

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Application

- In the Singaporean curriculum in addition to knowledge and understanding, Scientific and technological applications and implications are included in all themes
- In NGSS Contemporary STEM contexts are integrated into the standards
- Engineering, Technology and Applications of Science is a core idea, including Engineering Design and Links Among Engineering, technology, Science and Society

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Big Ideas

- In Singapore the curriculum is organised by themes to help students appreciate the big ideas in science.

- In NGSS The core ideas focus on Big ideas in science

- Cross cutting concepts encourage the development of the understanding of the Big ideas of science, enabling students to understand the full picture

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Introducing concepts at earlier ages

In the Singaporean curriculum the following topics are covered at Primary level whereas in the Thai curriculum they covered in the lower secondary curriculum:

- human and animal systems
- plant systems
- animal and plant nutrition
- classifying substances
- electricity and magnetism
- electrical circuits
- forces
- velocity, speed, and acceleration

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Additional content and more depth

The Biology GCSE syllabus goes into greater depth on
- Bioenergetics

The Chemistry GCSE syllabus goes into greater depth on
- Chemical changes
- Energy changes
- Chemical analysis
- Chemistry of the atmosphere
- Using resources

The Biology A level syllabus goes into greater depth on
- Cells and Stem Cells
- Exchange of substances with the environment
- Genetic information, variation and relationships in organisms
- Energy transfers in and between organisms
- The control of gene expressions

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Additional content and more depth

The A level Physics Syllabus goes into greater depth on:
- Fields and their consequences
- Nuclear physics
- Astrophysics
- Medical physics
- Engineering physics
- Turning points in physics
- Electronics

The A level Chemistry Syllabus goes into greater depth on for example:
- Energetics
- Kinetics
- Thermodynamics
- Equilibrium
- Radox

Group 2 and Group 7

Nuclear magnetic resonance spectroscopy

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Activity 1

1. As an individual choose 5 bullet points from the slides that you think are most important to address in your school.
2. Put the five bullet points you have chosen in order of importance
3. Score the most important 5, Second 4, Third 3, Fourth 2, and Fifth 1.
4. Put all your group scores onto a sheet of paper.
5, Calculate the total for each bullet
6. Identify the top 5 scores and put them in order 1 to 5
7. As a group discuss how you could address each of the top 5 and put them into practice in your schools.

Prepare to present the outcomes of your discussions

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Activity 1 Day 2

1. In your sector group discuss and identify how the themes can be embedded in your sector.
2. Brainstorm and select possible contexts for engaging your students in your sector.
3. Develop project ideas for your sector that fit within the contexts you have identified.
4. Summarise all your ideas on a poster.
5, Write 3 questions for people visiting your poster to answer - this will test their understanding of your ideas and make them read your poster carefully.
6. In your groups you will visit each poster. Answer the questions for the poster and also suggest how the ideas could be improved or give additional ideas.

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Activity 1 Day 3

- You are going to be involved in a cooperative learning approach called jigsaw technique that will enable you to develop an understanding of the STEM modules.
- You are currently in your '**home group**'
- Give each member of your group one of the module title cards. These are the **expert** name cards.
- When you have been given your expert card pair-up with the other member of your home group with the same expert card.
- You are going to become an expert in the STEM module with the title on your expert card.
- With your partner go to a table with your expert name. You will be working with three others pairs from other groups who have the same expert card. This is your '**expert group**'.

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Expert group task

- In your expert group read, discuss and answer the questions on the following slide by reading the STEM module assigned to your expert group.
- This will help you to understand the STEM module from both a student and teacher perspective.
- Make sure that each member of your expert group has the answers to all the questions and completely understands your STEM module.
- Prepare to present your STEM module to your home group by using the answers to the questions as a structure.
- When everyone has completed the expert task you will return to your home group

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Home group task

- Return to your home group.
- Each expert pair should present their STEM module to the home group and ensure that all members of the home group understand the module by providing additional explanation and by answering any questions the home group has with regard your module.
- When you have shared all three STEM modules go through the process of preparing to use the STEM module your home group has been assigned by discussing and answering the questions on the next slide.
- Prepare to present your STEM module by summarising your discussions on a large sheet of paper.

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