مدرسة قطر للعلوم و التكنولوجيا الثانوية للبنين
Qatar Science & Technology Secondary School for Boys

2023/2022

QSTSS Curriculum Framework

Version 2: May 2022

Contents

1. Introduction to the school
2. School vision and mission
3. The aims of the Qatar Science and Technology Secondary School (QSTSS) curriculum framework
4. The context: the Qatar National Vision (QNV) 2030
5. The context: the Qatar National Curriculum Framework (QNCF).
6. The QSTSS curriculum:
    - 6.1. Design principles
    - 6.2. Curriculum Aims
    - 6.3. Curriculum Objectives
    - 6.4. Characteristics of the STEM approach at QSTSS?
    - 6.5. Curriculum architecture and content (Grades 9-10)
    - 6.6. Curriculum architecture and content (Grades 11-12)
7. Curriculum planning and delivery strategies.
8. Student assessment.
9. Induction and continuing professional development programs for staff.
10. The Quality Assurance process: Curriculum Review.

Appendix One. Quality Indicators: The STEM Curriculum

Appendix Two. The Teaching of STEM at QSTSS school

الرؤية : تمكين الطلبة من مهارات القرن الواحد والعشرين، وإعدادهم للمساهمة الفاعلة في بناء الاقتصاد الوطني القائم على المعرفة والتطور العلمي و التكنولوجي.
Vision : Empowering students to develop the 21st century skills and preparing them to contribute effectively to building a national economy that relies on knowledge along with scientific and technological advancements.
Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

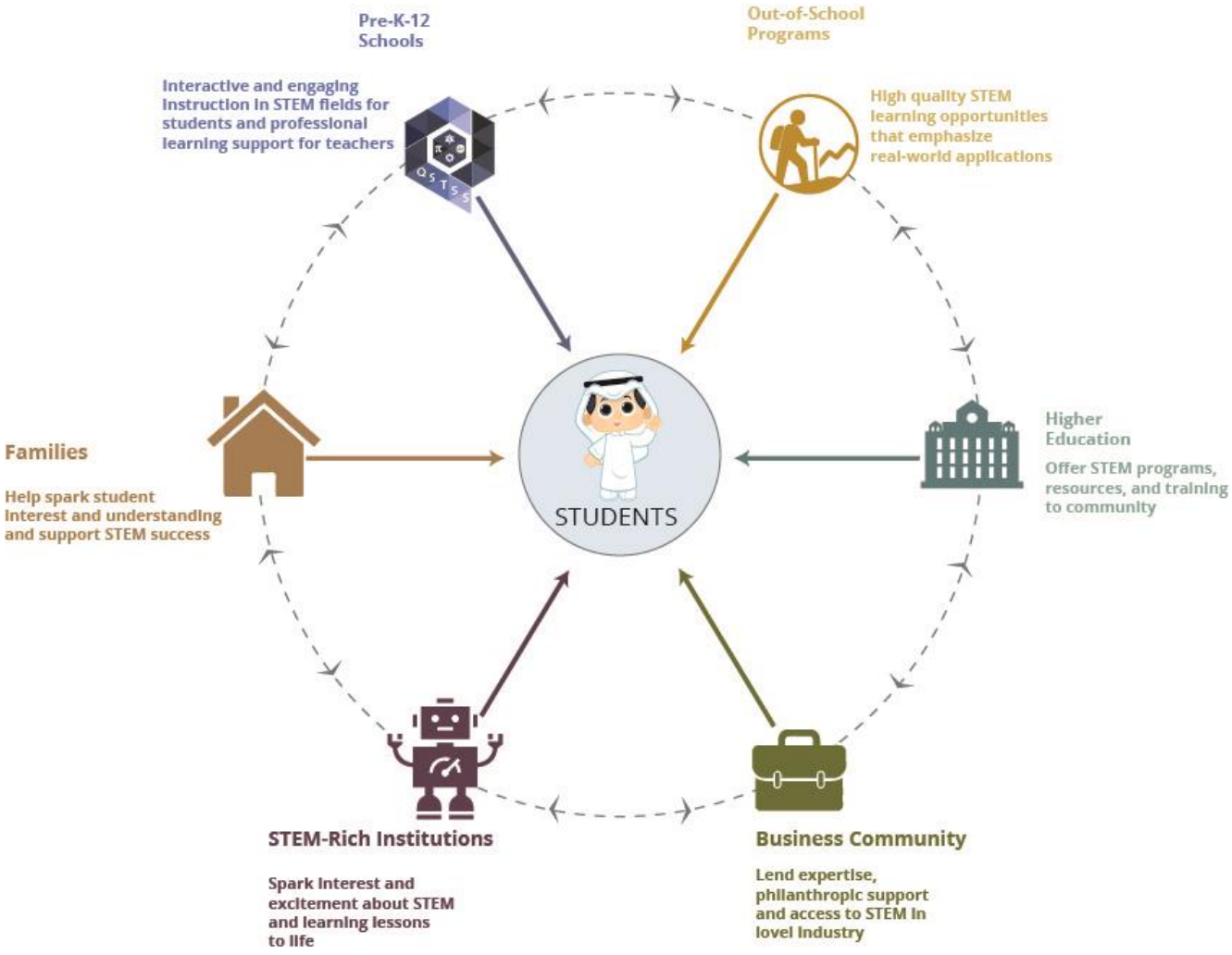
1. Introduction to the school

Qatar Science and Technology School for Boys (QSTSS) is a specialized government STEM (Science, Technology, Mathematics, and Science) school, operating under the umbrella of the Ministry of Education and Higher Education (MOEHE).

The school was launched in August 2018 and seeks to provide a trans-disciplinary STEM program that focuses on the development of hands-on science skills, creativity, and innovative thinking. Such an approach allows students to apply their knowledge and skills to authentic local, regional, and global challenges using cutting-edge technologies. The school provides access to high-quality learning experiences, both in the classroom and in specialized laboratories. Students are supported by highly qualified and experienced teachers and engineers who are specialists in the field of STEM education.

A fundamental principle that underpins effective STEM education programs is that emphasize the real-life application of STEM knowledge and skills to authentic real-life situations, problems, and challenges. Therefore, in addition to the formal school-based curriculum, QSTSS is keen to interact with the wider community, recognizing the benefits that will accrue to both our students and to the general population. We are committed to engaging with, drawing on, and partnering with a wide range of external organizations, as exemplified by the STEM ecosystem concept developed by the OregonASK Expanded Learning Project https://oregonask.org/stem/

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa



2. School Vision and Mission

Vision: Empowering students to develop 21st-century skills and preparing them to contribute to building a national economy that relies on knowledge, along with scientific and technological advancements.

Mission: To provide innovative, engaging, and challenging learning experiences in science, technology, engineering, and mathematics in a trans-disciplinary way that enables students to develop their skills in research, design, critical thinking and problem-solving, and contributes to building their creativity and competitive capabilities globally.

3. The aims of the QSTSS Curriculum Framework

The QSTSS curriculum framework seeks to:

- Provide a coherent framework for the planning and delivery of the curriculum
- Define the curriculum content in terms of subject content, subject-specific skills, STEM-related skills, and generic skills
- Identify an organized set of standards/learning that defines the content students will be expected to know, understand, and do by the end of their time in the school (currently grades 9-12)
- Define the curriculum architecture required to provide an integrated, multi-disciplinary, and inter-disciplinary approach to the planning and delivery of a curriculum appropriate for a STEM school
- Ensure that there is consistency and balance between intended learning outcomes, the student learning experience, and student learning outcomes.
- Provide the baseline for both formative and summative student assessment strategies and activities
- Establish the principles against which current and future decisions about the architecture, content, and delivery of the curriculum will be evaluated
- Inform continuing professional development policies and programs
- Provide appropriate criteria and indicators for the evaluation, review and revision of the curriculum and educational programs
- Provide criteria against which school effectiveness can be evaluated.
- Facilitates the transfer of the curriculum to future STEM schools in the State of Qatar

4. The Context: the Qatar National Vision 2030

The Qatar economy is at the forefront of global development. In the fields of technology and media communications, Qatar is playing a leading role in the world. To maintain this position and respond to its challenges, the school curriculum must be aligned to the very latest developments and must equip young people to take their place in a very advanced economy and society. Learning must continue through life and draw on the latest technological possibilities.

The Qatar National Vision (QNV) 2030 considers human development to be its cornerstone 'because no development and no progress can be accomplished without advanced high-quality education and training services that are aligned with the labor market needs and the aspirations and abilities of each individual.'

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

One of the prime objectives of the QNV is to transform Qatar into a knowledge-based economy, characterized by sustainable development based on research, development, and innovation, excellence in entrepreneurship, and high levels of education.

The provision of schools with a STEM focus is totally compatible with these aspirations and provides an excellent foundation for their realization.

5. The Context: the Qatar National Curriculum Framework (QNCF).

The QSTSS curriculum is fully compatible with the Qatar National Curriculum Framework (QNCF), which identifies several key values, aims, and principles that underpin the curriculum. These are equally relevant as a starting point in relation to the curriculum offered at QSTSS.

QNCF key values:

- Respect and compassion
- Positivity and endeavour
- Personal rights, responsibility, and integrity

QNCF key aims:

- Successful life-long learning
- Personal, moral, and social development
- Active and responsible citizenship

QNCF key principles:

- Excellence
- Inclusiveness (education for all)
- Openness and flexibility
- Balance
- Relevance
- Integration and coherence

Students successfully engaging in the QSTSS curriculum will automatically satisfy the negotiated requirements imposed by the subject-based curriculum followed in other Qatari state schools and will meet the levels of achievement required for graduation. Successful graduates will receive a Specialized

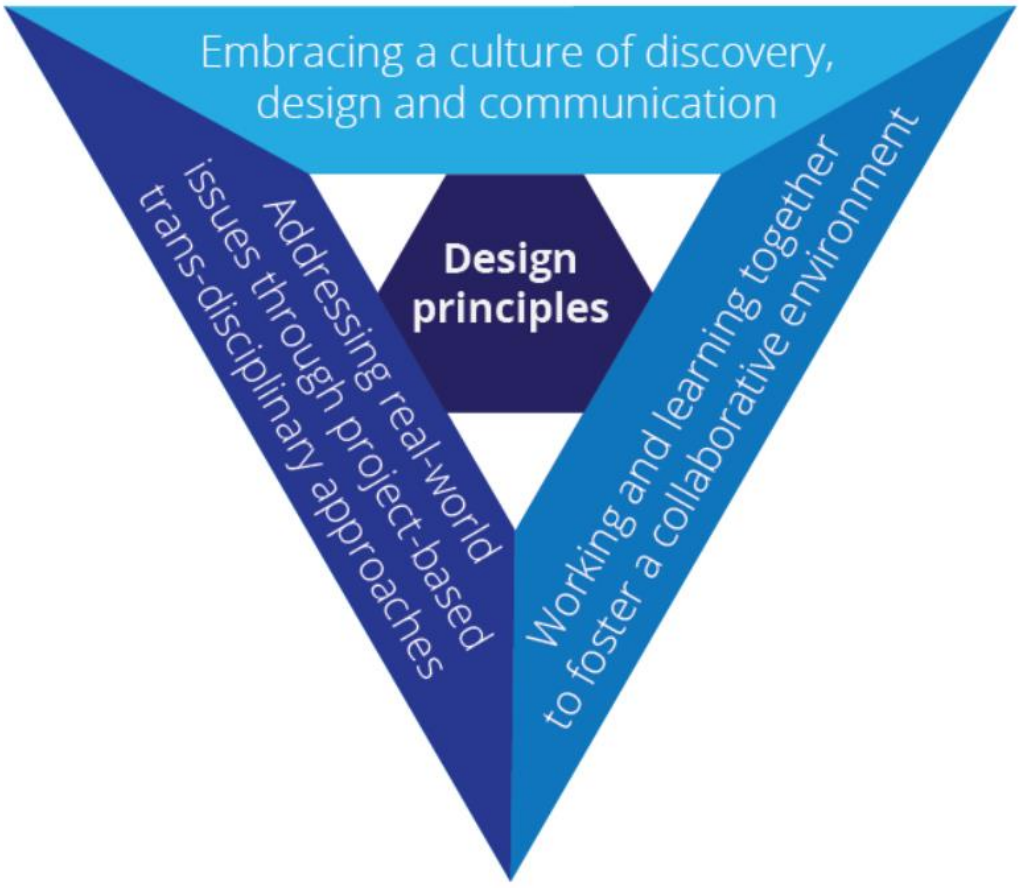
Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

Education High School Certificate, in addition to a range of additional international qualifications including the AP courses, SAT, ACT, and IELTS.

6. The QSTSS curriculum

6.1. Design principles

Using a STEM education framework, QSTSS seeks to develop a unique approach to teaching and learning that fosters creativity and innovative thinking in all students. Through its education program, QSTSS strives to produce the kind of thinkers, innovators, and problem solvers who will be successful in a competitive global society. Therefore, the STEM curriculum offered at QSTSS has been built on three design principles:



- **Embracing a culture of discovery, design, and communication.**

  Students are naturally curious and try to make sense of the world through their own experiences. Therefore, the curriculum should embrace the concept of inquiry and encourage students to question the world in which they live. Teachers are required to make use of the design process in all phases of their work, using it as a structure that encourages discovery and problem-solving. Students are encouraged to become designers of their own learning experiences.

- **Addressing real-world issues through project-based trans-disciplinary approaches.**

  QSTSS is committed to the concept of a learner-centered approach that places relevant issues and real-world problems at the centre of instructional design. Student learning is contextualized and characterized by a focus on making and doing, not consuming. The learning process is equally as important as the learning outcomes, and students document their journey along the way. As a culminating step, students share their learning through presentations and evidence-based discussions.

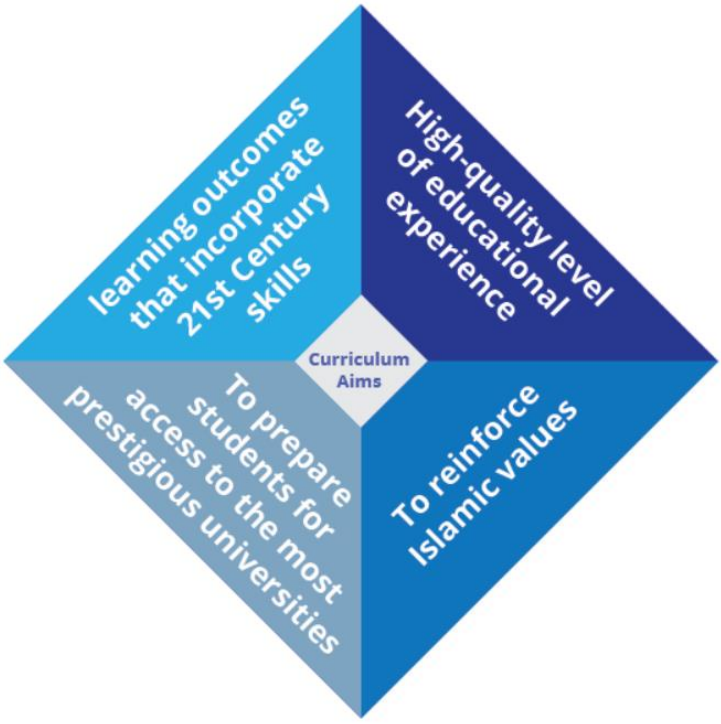
- **Working and learning together to foster a collaborative environment.**

  Teachers and students learn by doing, sharing, and connecting with others. Learning extends beyond the classroom and the school walls. We collaborate with stakeholders from every walk of life and all school partners are engaged in an array of opportunities in leadership, internships/fellowships, mentorships, and service-learning roles. We are an integrated community of practice.

6.2. Curriculum Aims.

QSTSS is a STEM-focused school that has four central aims:

1. To provide learning outcomes that incorporate 21st Century skills to build a knowledge-based national economy
2. To deliver a high-quality level of educational experience in science, technology, engineering, and mathematics
3. To prepare students for access to the most prestigious universities that qualify them to become distinguished scientists, researchers, and inventors.



4. To reinforce Islamic values, as well as national and ethical values, among all students

6.3. Curriculum Objectives

Our central objective is to provide a learning environment that enables students to realise the QSTSS aims. To this end, our Learner Profile identifies the skills and qualities we seek to develop with students, who will become:

1) **Critical and creative thinkers**, who use critical and creative thinking skills to analyze and act in relation to real-life challenges and opportunities.
2) **Communicators and collaborators**, who express themselves confidently and creatively in numerous ways and collaborate effectively with others to achieve desired results.
3) **Problem solvers**, who see problems as challenges and life experiences and try to adopt an objective overview.
4) **Inquirers**, who are curious and possess the skills needed to conduct inquiries and research. They are enthusiastic and aspire to be life-long and independent learners.
5) **Innovators**, who utilize STEM design thinking to create new ideas and solve problems in new ways.
6) **STEM literate** individuals who can utilize concepts from science, technology, engineering, and mathematics in order to understand complex problems and to innovate with others to solve them.
7) **Digitally literate individuals**, who can find, evaluate and compose clear information through writing and other mediums on various digital platforms.

8) **Disciplined and responsible individuals**, who act with integrity and honesty, with a strong sense of fairness and justice, and with respect for the dignity and rights of people everywhere. They take responsibility for their actions and the consequences.
9) **Ethical and caring individuals**, who exemplify Islamic and human moral values, show compassion, and respect for others and constantly work to make a positive impact on their lives.

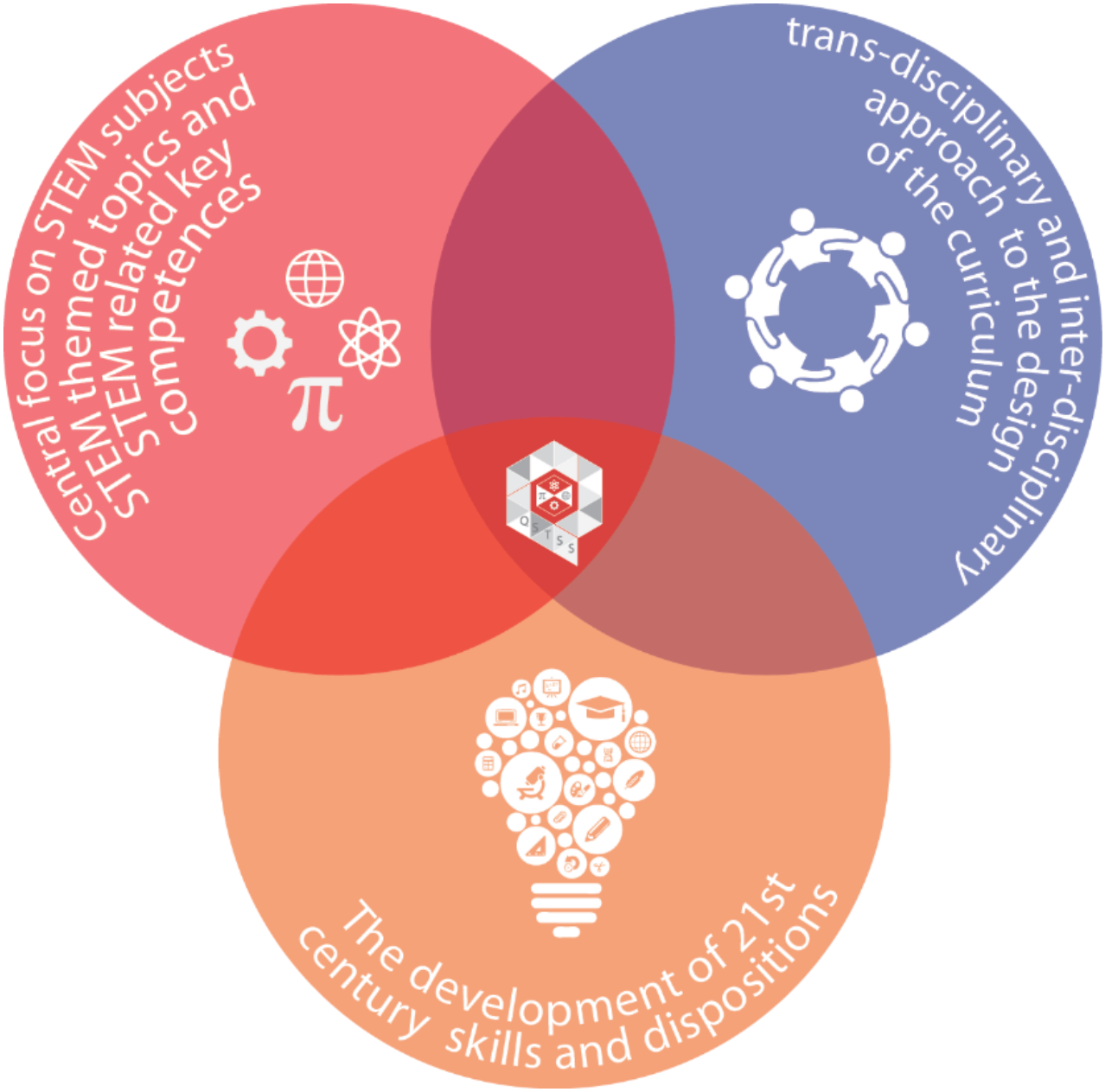
6.4. Characteristics of the STEM approach at QSTSS?

At QSTSS, an integrated STEM education approach occupies a multidimensional space in the school's academic program. Rather than providing a single, closely-defined experience, it involves a range of experiences with a high degree of connection. The experiences may occur in one or several class lessons, or throughout the curriculum. They may be reflected in the organization of a single course or the entire school, or they may be presented on after- or out-of-school activities.

The STEM element of the curriculum at QSTSS is in line with the international standards identified in documents such as: The European STEM Schools Report: Key Elements and Criteria Article - January 2018 https://www.researchgate.net/publication/332189909, and the STEM Certification standards and indicators developed by Cognia: https://www.advanc-ed.org/sites/default/files/documents/state-resources/STEM-Certification-Overview.pdf

The QSTSS Curriculum Content is Characterized by:

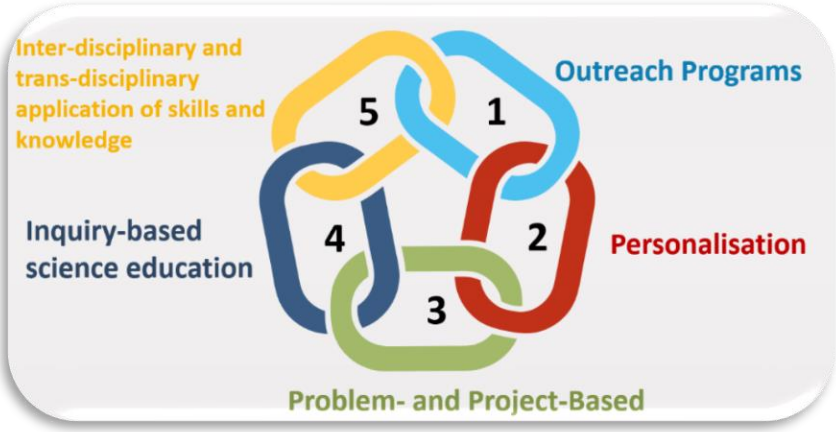
- **A central focus on STEM subjects (Science, Technology, Engineering and Mathematics), STEM themed topics and STEM related key competences**. All other areas of the curriculum reflect core STEM learning objectives.
- **A trans-disciplinary and inter-disciplinary approach to the design of the curriculum.** Teachers actively seek to design the curriculum from a holistic, integrated, inter-disciplinary and trans-disciplinary perspective.
- **The development of 21st century skills and dispositions.** We actively develop learning and innovation skills, STEM literacy skills, digital literacy skills, and life and careers skills.



Curriculum Delivery at QSTSS is Characterized by:

The QSTSS Student Learning Experience is Characterized by:

- **Outreach.** We seek to reach out to and inspire students who would not normally be interested in STEM subjects or consider opportunities for higher education study or employment in STEM-related areas.
- **The personalisation of learning.** Our instructional approaches address the different learning needs, interests, and cultural backgrounds of students.



- **A problem- and project-Based learning approach (PBL).** Our student-centred pedagogy enables QSTSS students to learn about subjects by solving open-ended problems and/or by developing projects, either individually or collaboratively.
- **Inquiry-based science education (IBSE).** The learning process at QSTSS provides an environment in which questions, problems and scenarios are presented to students, including case studies, fieldwork, investigations, or original small-scale action-research projects.
- **An inter-disciplinary and trans-disciplinary application of skills and knowledge**. Rather than teaching the four disciplines as separate and discrete subjects, the STEM approach at QSTSS integrates them into a cohesive learning paradigm, based on real-world applications.

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

QSTSS Infrastructure and Resources are Characterized by:

- **Access to high quality instructional materials.** QSTSS instructional materials support our STEM objectives of providing a learning experience that is trans-disciplinary, innovative, creative, inquiry-based, project-based, problem-based, and research-based.
- **Access to state-of-the-art technology and equipment.** QSTSS students can work in well-equipped and state-of-the-art specialist laboratories and workshops in order to develop and practice their skills.

The QSTSS Teaching Body is Characterized by:

- **The employment of highly qualified professionals.** QSTSS teachers, instructors, engineers, and support staff are highly qualified and experienced in the field of STEM education.
- **The provision of high quality and specialized continuing professional development opportunities (CPD) for pedagogical staff.** Initial and continuous professional development opportunities are provided for all our staff: principal, vice-principals, STEM coordinators, heads of department, teachers, engineers, and career counsellors.

Our role in the wider community is characterized by:

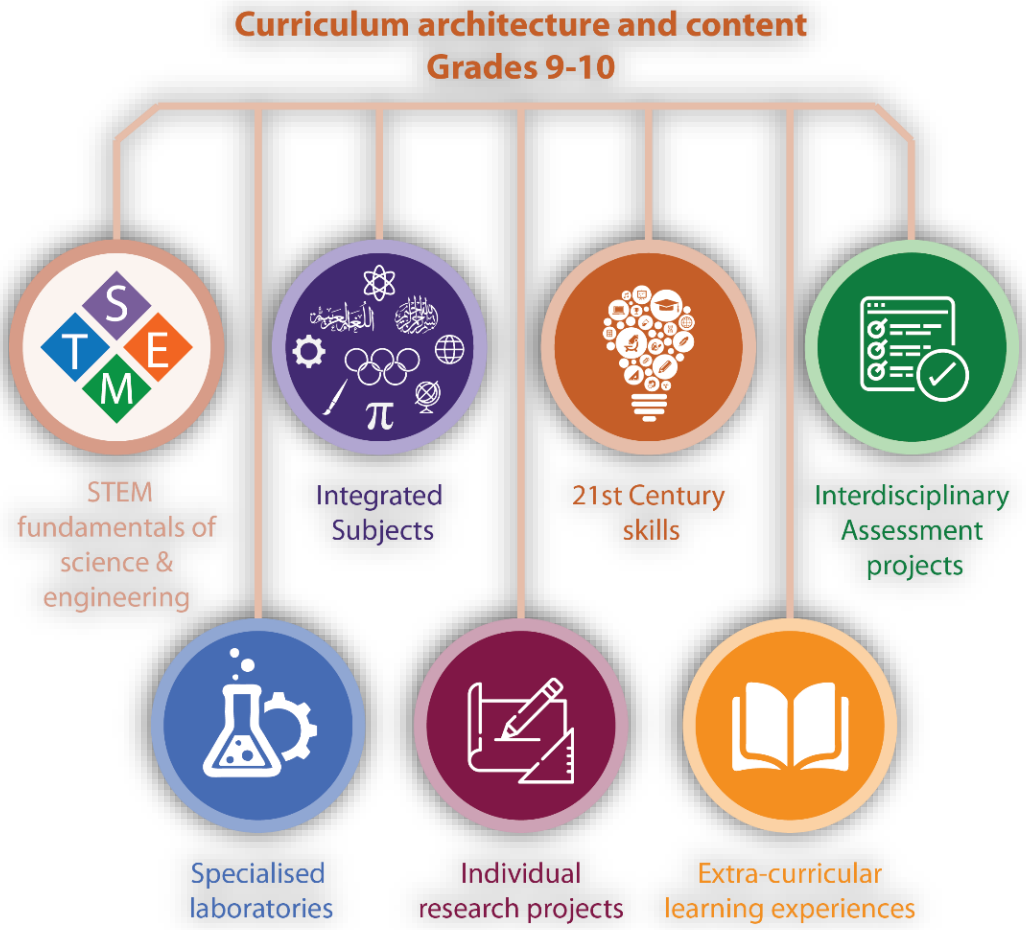
- **The development of effective partnerships with business and industry**. QSTSS seeks to work closely with local business and industry interests to further student interest in authentic opportunities and challenges in STEM related fields and in order for them to gain insights and real-life experiences.
- **The development of effective partnerships with parents and guardians.** Our school seeks to develop awareness among parents in relation to STEM related higher education and employment opportunities so they can both support and advise their children.
- **The development of effective partnerships with other schools.** QSTSS seeks to form partnerships with other STEM schools to foster and support local, regional and global initiatives. In addition, we reach out to non-STEM schools in the local and national arena to foster interest and develop foundation programs that facilitate the development of awareness, knowledge and skills.
- **The development of effective partnerships with Further and Higher Education bodies.** QSTSS seeks to actively engage with relevant further and higher education bodies to initiate articulation agreements, support the development of collaborative programs and effect a seamless and effective transfer process for its students.

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

For further details, see Appendix One. (Quality indictors: The STEM curriculum)

6.5. Curriculum architecture and content. Grades 9-10.

In order to achieve the school's aims and objectives, the QSTSS curriculum framework comprises eight main aspects in grades 9-10.



1. **STEM:** The fundamentals of science and engineering
2. **Integrated Subjects:** Mathematics, ICT, DT, Arabic, English, Islamic Studies, Social Studies, P.E. (integrated & aligned with STEM through the development of specific projects)
3. **Integrated 21st Century skills.**
4. **Interdisciplinary assessment projects.**
5. Learning experiences in specialist laboratories (Energy, Robotics, Digital Fabrication, & Biomedical Sciences)
6. **Individual research projects,** supported by a supervisor.

7. **Extra-curricular learning experiences**, including university programmes, STEM-related competitions, and projects.

6.5.1. STEM: The Fundamentals of Science and Engineering

This aspect of the curriculum focuses on basic science concepts and their connections to everyday life through different engineering designs and applications. The curriculum was constructed with reference to Next Generation Science Standards (NGSS) and Qatari National Curriculum Science Standards (QNCSS). It draws on international expectations of what students should know, understand and be able to do by the end of grades 9 and 10.

The curriculum has been developed for QSTSS by an international team of curriculum experts, guided by the science supervisors of the Ministry of Education and Higher Education (MOEHE). STEM and AP teachers and curriculum specialists have reviewed the curriculum to ensure that the STEM curriculum reflects Qatari values and culture and that it is relevant to the educational and social needs and interests of Qatari students. In addition to the acquisition and application of knowledge, the STEM curriculum at QSTSS actively develops the critical thinking, inquiry, and reasoning skills that ensure students develop the ability to think in innovative and creative ways, think analytically, and solve problems.

The STEM curriculum in Years 9 and 10 prepares students for the requirements of AP programs in Years 11 and 12, thus facilitating access to elite universities.

The STEM department takes full advantage of the well-equipped laboratories available in the school to strengthen the student's knowledge and/or to introduce new topics. The STEM curriculum is underpinned by a Scope and Sequence chart that provides an overview and summarizes the content to be taught in grades 9 and 10 and pinpoints the links to the AP courses to be taught in grades 11 and 12. The NGSS and QNCSS standards have been grouped into thematic strands as follows:

1- **Science:** Scientific Enquiry, Physics, Biology, Chemistry, and the Earth.
2- **Technology:** is used as both a tool and as an output.
3- **Engineering:** The engineering design cycle is emphasized throughout nearly all areas of the STEM curriculum.
4- **Mathematics:** reasoning and problem-solving, number and algebra, geometry and measures, and data handling.

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

In each strand, standards are grouped into topics. The standards from Grades 9 and 10 form the basis of an obligatory study program for all students.

The aims of the STEM Curriculum

The overall goals of the STEM curriculum are that students should:

1) develop and sustain an interest in science and its applications.
2) understand scientific methods and design cycles and the way that science has developed over time.
3) be proficient in the use of a range of techniques and in handling apparatus.
4) use technology and ICT effectively in the pursuit and communication of science.
5) apply scientific inquiry skills and the engineering design cycle in both familiar and unfamiliar situations and communicate the outcomes of their inquiries in appropriate ways.
6) have a sound and systematic knowledge of important scientific facts, concepts, and principles, and possess the skills needed to apply these in new and changing situations in a range of personal, domestic, industrial, and environmental contexts.
7) recognize the importance of the application of scientific knowledge in the modern world and be aware of the moral, ethical, social, and environmental implications.
8) explain natural phenomena and their limitations.
9) understand and clearly communicate a range of fundamental concepts that underpin branches of modern science.

The main textbooks/resources used in grades 9 and 10 are:

- Fundamental Science and Engineering, volumes 1 and 2. Pasco Education

Supplementary resources include:

- College Physics. Serway, 11th ed.
- Chemistry. Zumdhal et al., 10th ed.
- Biology. Campbell, 10th ed.

Frequent use is made of the STEM Laboratory, the Virtual Reality Laboratory, the Robotics Laboratory, the Augmented Reality Laboratory, and the Energy Laboratory

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline

- An identification of the alignment between the STEM curriculum, the 21st Century skills, and the curriculum learning objectives of other subjects.

For further details, see Appendix Two. (The Teaching of STEM at QSTSS school)

6.5.2. Mathematics, ICT, DT, Arabic, English, Islamic Studies, Social Studies, P.E. (integrated with STEM through the development of specific projects)

6.5.2.1 Mathematics

In grades 9 and 10, there is a recognition that the course contents are important for facilitating student success in college mathematics entrance examinations. Students who complete Algebra 1and Algebra 2 should be able to then take Pre-Calculus.

Major topics covered in the course during grades 9 and 10:

- **Algebra** 1: This course is designed to emphasize the study of multiple representations of linear and non-linear functions. It includes mathematical concepts for working with rational numbers, various expressions, analysing and solving linear equations and inequalities, data analysis, probability, statistics, and polynomials. Students use hands-on materials and calculators when needed in solving problems where the algebra concepts are applied. Students who complete Algebra I proceed to Geometry.

- **Geometry**: This course is designed to emphasize the study of the properties and applications of common geometric figures in two and three dimensions. It includes the study of transformations and right triangle trigonometry. Inductive and deductive thinking skills are used in problem solving situations, and applications to the real world are stressed. It also emphasizes writing proofs to solve (prove) properties of geometric figures. Students who complete Geometry proceed to Algebra II

- **Algebra** 2: This course is designed to build on algebraic and geometric concepts. It develops advanced algebra skills such as systems of equations, advanced polynomials, quadratics, and includes the study of trigonometric functions. It also introduces advanced statistical distributions.

The main textbooks/resources used in grades 9 and 10 are:

- Reveal Math Integrated I, II, III, & Pre-calculus by McGraw hill publishers.
- IGCSE International Mathematics. Haese and Harris Publications, (0607) Extended
- Fundamental Sciences and Engineering. Pasco Education
- IXL interactive learning website

- Khan Academy Website.

Use is made of the Virtual Reality Laboratory.

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the mathematics curriculum, the 21st Century skills, and the STEM curriculum learning objectives.

6.5.2.2. Information Communication Technology (ICT)/Computer Science (CS).

In grade 9, the ICT/CS course is designed to help students develop skills and knowledge in the practical uses of the most frequently used software packages required in the modern workplace (including MS Office, MS Teams, OneNote, and OneDrive). The skills taught in the course enable students to use their knowledge to conduct research, and to design and present their STEM projects in the most effective manner.

During the course, students can link their learning with Science, Engineering, and Mathematics. Excel formulas require an intermediate level of Mathematics. The topic highlights the importance of syntax when using Formulas and Functions. Data representation is done through research and the presentation of data graphically through the means of charts and graphs. Students learn a variety of methods for making presentations to an audience. Microsoft packages are interlaced to create powerful and concise presentations. The use of communication technologies is important in the present times. The skills and protocols for communication allow for producing professional emails, letters, and conferencing experiences.

Python is the chosen language of delivery for programming. It is easy for beginners to learn and is widely used in many scientific areas for data exploration. Students are introduced to the Python programming language through the Minecraft game as it allows them to involve themselves deeper with the subject. The course introduces data types, control flow, object-oriented programming, and graphical user interface-driven applications.

In grade 10, students take part in the Artificial Intelligence Fundamentals course, which provides them with a profound understanding of the basic techniques for building intelligent computer systems. It provides students with an opportunity to learn how Artificial Intelligence (AI) can be used to make a

computer learn, plan, and solve problems autonomously. Students learn how to equip a computer with different AI technologies that allow it to think, behave, reflect, and interact like a human.

The course begins with an introduction to what Artificial Intelligence and Machine Learning are, with a focus on AI ecosystem and AI agents followed by an explanation of types of AI (strong, weak, narrow, and broad) and their real-world applications. Additionally, the course enables students to master various technical skills to further elaborate on how AI can be used for problem-solving by introducing different topics such as Types of Machine Learning (supervised and unsupervised), Decision Trees, Classification, Regression, Clustering, and Overfitting.
Student learning experiences are based on a Project-Based Learning approach. They use APIs from IBM-Watson to train machine learning models to recognize text, numbers, images, or sounds.

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the ICT curriculum, the 21st Century skills, and the STEM curriculum.

6.5.2.3. Design Technology

In grade 9, the course involves a study of both designing and producing. This is explored through areas such as design theory and practice, design processes, environmental and social issues, communication, research, and the manipulation of materials, tools and techniques.

The course involves hands-on practical activities which develop knowledge and skills in designing and producing. The Preliminary Course includes the completion of at least two design projects. These projects involve the design, production and evaluation of a product, system, or environment and includes evidence of the design process recorded in a design folio. The design folio can take a variety of different forms.

In the Design Technology class, the students learn how to use SolidWorks software in order to know how products are designed and manufactured, how to be innovative and to make creative use of a variety of resources including digital technologies, to improve the world around them. Design Technology supports the teaching of other subjects, such as pre-engineering and fabrication lab classes.

In grade 10, students learn how to use programs such as Photoshop to learn the basics of 2D design skills, as well as how to produce printing materials. They are provided with the skills that enable them to design their own projects and supporting designs.

In MS web expression, students learn the concepts of web design, and how to design their own web pages and develop the skills needed to launch their projects within other subjects.
Students learn how to be innovative and to make creative use of a variety of resources, including digital technologies, in order to improve the world around them. Design Technology supports the teaching of other subjects, such as pre-engineering and fabrication lab classes.

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the DT curriculum, the 21st Century skills, and the STEM curriculum.

6.5.2.4. English Language

In grades 9 and 10, the main objective of the course is to enable students to develop their English language skills to the level required for competition in the labor market and enrolment in higher education. This is achieved through developing student competencies and skills in relation to the functional aspects of the language. This course aims to enhance student awareness of reading, listening, and writing strategies in an integrated way and improve their speaking skills. Students are exposed to vocabulary related to STEM topics during the lessons to expand both their passive and active lexicon. In addition, an emphasis on critical thinking skills is adopted in daily lessons to enable students to gain a deeper understanding of the world and enhance their creativity.

The main textbooks used in grade 9 are Pathways Reading, Writing, and Critical Thinking and Pathways Speaking, Listening, and Critical thinking. Additional resources include novels, IELTS and SAT practice activities, IXL, ReadWorks and TED talks, and Achieve 3000 from McGraw Hill.

Use is made of the Language Laboratory and the Digital Library.

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the English curriculum, the 21st Century skills, the STEM curriculum, and subject-based learning objectives.

6.5.2.5. Arabic Language

In all grade levels, the Arabic language curriculum at QSTSS follows Qatar's national curriculum standards and is authorized by the Ministry of Education and Higher Education, and is presented through the ministry's learning sources, and focuses on the understanding of the "standard" Arabic language in its vocal, grammatical, compositional, spelling, lexical, rhetorical and stylistic levels, and its functional use in different cognitive and communication contexts, read, written, spoken and listened. The Arabic language curriculum also seeks to enable students to learn the rules of literary and non-literary writing and use them to produce different functional and creative texts and speeches, to use language to develop critical and creative thinking skills, develop research, exploration and problem solving skills, keep up with the times in the use of technologies in the field of linguistic communication, and develop students' pride in national identity, respect religious values, communicate with the cultural heritage of the nation, and deepen its affiliation.

The Arabic curriculum aims to develop students' language proficiencies in reading, writing, speaking, and listening, which are consistent with other basic skills, and come to meet the skills envisaged in the 21st century, such as critical thinking, creative thinking, communication, collaboration, participation, research, investigation and problem solving.

In the field of critical thinking, the approach prompts learners to choose information and facts, to identify them, to formulate hypotheses and predictions, through readable and audio texts, to train them in classification skills, to search for information from a variety of sources, to detect their accuracy, to employ them and use them in the appropriate context, which will earn them critical thinking skills.

In the field of creative thinking, the curriculum focuses on making skills learning a fundamental outcome, while stimulating the production of knowledge and effectively applying the impact of learning, by developing learners' ability to write and speak, use imagination and metaphors and

integrate information, and to be fluent in different language skills, to allow for their independence and creativity, and to encourage them to produce new, innovative viable ideas.

Communication: The curriculum promotes communication, acceptance, criticism, and analysis through reading, reading, researching diverse sources, listening and listening, and encouraging learners to communicate thoughts and feelings using body language and vocal toning.

Cooperation and collaboration: The ability to cooperate with others and participate in group and community activities is very important in many contexts, so the Arabic language curriculum is mainly concerned to foster students' ability to respect the viewpoints of others, their personal qualities, and contribute positively to teams and groups by participating in bilateral and group discussions by employing the right language, and forming scientific teams to arrange and provide information.

Investigation and research: The Arabic language curriculum encourages learners to acquire knowledge, skills and attitudes related to investigation and research, curiosity and questioning about many of the issues, and encourages the learners to develop their methods of obtaining and analyzing important information, researching various sources, employing technology in this, and participating in research and information networks.

Problem Solving: The ability to solve problems is one of the most important competencies of the 21st century in the light of the complexity of the world today, so the end of the Arabic language develops problem-solving activities in a context related to other skills such as creative thinking, criticism, communication, research, cooperation and collaboration, thus contributing to making the learner able to identify problems, propose solutions and develop them with others in the context of problem solving and positive attitude towards change.

In order to achieve the objectives of this curriculum and its lofty objectives, teachers at QSTSS adopt interesting, attractive and effective methods and strategies for communicating information, utilizing various technologies to gain knowledge and apply those strategies, achieving the integration of Arabic language material and other subjects, and most importantly with STEM, to prepare a learner who is capable of using the language efficiently, fluently, accurately and easily in various fields of cultural, professional and practical life.

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the Arabic curriculum, the 21st Century skills, and the STEM curriculum.

6.5.2.6. Social Studies

The Social Studies course is designed to cover four areas: Qatar history, the geography of Qatar, citizenship, and the history of Islamic scholars. It is delivered in Arabic and it is only delivered to grade 9 students. The subject is designed to support an inquiry and research-based learning approach, critical thinking and communication skills. The text book used for this course I specially designed for the school by the MOEHE team and advisory board of university professors from Qatar University.

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the Social Studies curriculum, the 21st Century skills, and the STEM curriculum.

6.5.2.7. Islamic Studies

In all grade levels, the Islamic Education Curriculum at QSTSS follows Qatar's national curriculum standards approved by the Ministry of Education and Higher Education and is provided through the ministry's learning sources with special adaptation that takes into account the number of subject quotas within the school.

The contents of Islamic education contribute to understanding the reality of the universe, understanding the wisdom of god's creation of beings, identifying the Muslim learner, understanding and appreciating his culture and traditions, as well as developing the spiritual dimension of the human personality, and developing the moral and social competences necessary for family life, as well as for the social and professional life of the individual. It also contributes to the development of a spirit of tolerance and respect for other religions based on mutual cultural dialogue and faith.

The Islamic education curriculum focuses on the development of students' knowledge and skills in the six fields of Islamic education, namely, the field of the Holy Quran, where the student applies the provisions of intonation correctly in what he reads or memorizes, and interprets the surah and verses correctly. Then the field of Islamic jurisprudence and its origins, where the student learns about the practical provisions that confront him in his life, and then learns the parameters of the biography of the Prophet (pbuh) and the method of dealing with life, expressing his faith in him, and his love for him, and the conclusion of the article in the field of Islamic ethics and morals, which promotes the Islamic morality of the student in his relationship with Allah Almighty, and with his Messenger of Creation and with him.

It also aims to develop their orientation through planting and valuable construction, which is done through the lessons of the subject or in cooperation with the school committees through the classroom and extracurricular activities of the Qiam (Values & Ethics) center and the activities committee. The curriculum is presented through innovative, interactive teaching methods that take into account the complementary orientation of materials, and develop the basic skills and skills of the 21st century in students, including the development of linguistic competences through reading texts, recitation, understanding the meanings of words and Islamic terms in the light of linguistic meanings by referencing language dictionaries, developing research and investigation skills by reference to the original sources and references of books and periodicals, and electronic as platforms, sites, encyclopedias and dictionaries, in order to understand the provisions and the meanings of research and research, and to provide research and research in the course of the research and evaluation process, in order to understand the provisions and the meanings of the research and research, in order to introduce the concepts of the research and research. The article also supports the adequacy of communication in its written and verbal forms and takes into account what strengthens the communication of students through attention to their presentations and written communication through the means of communication adopted by the school and the ministry.

All of this is achieved through a set of educational and evaluation programs and strategies, electronic, applied, mental, cooperative and subjective.

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the Islamic Studies curriculum, the 21st Century skills, and the STEM curriculum.

6.5.2.8. Physical Education (P.E.)

The physical education courses (9-12) at QSTSS follow the guidelines and requirements of the MOEHE P.E curriculum. Physical education offers possibilities for the development of several competencies that are important to what it means to be an educated human being. They are life skills in the sense that to omit them from a young person's education would be to be negligent of their future flourishing as human beings. Physical education is concerned with children and young people learning in, about, and through movement, where recognized and culturally valued forms of physical activity are the medium for learning. This key characteristic of movement as the medium for learning distinguishes physical education from other curriculum areas and provides physical education's unique contribution to children's education.
The physical education curriculum focuses on the development of 6 main competencies including:

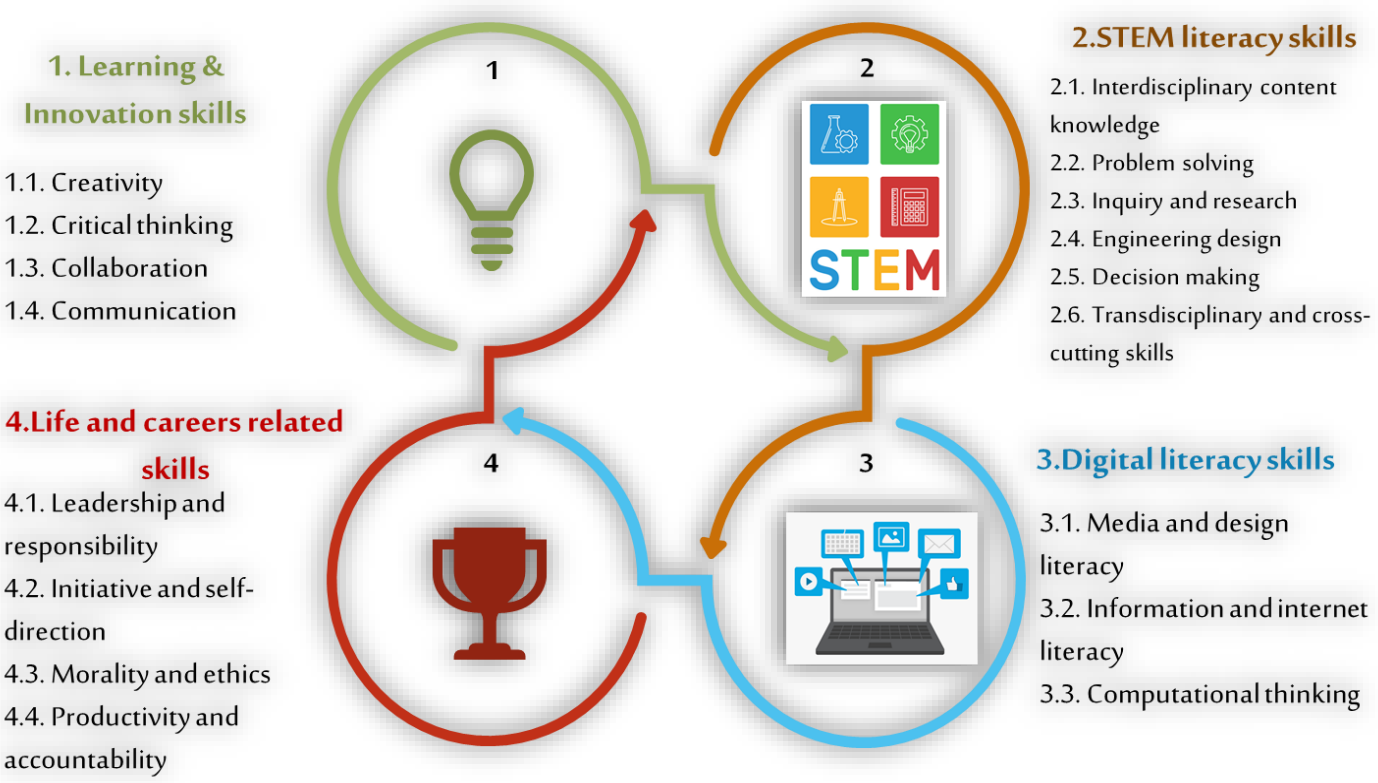
- Movement competence.
- Valuing physical activity
- Physical activity for health and wellbeing
- Managing risk and safety in movement environments
- Playing sport
- Appreciating movement aesthetically

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the PE curriculum, the 21st Century skills, and the STEM curriculum.

6.5.3. Integrated 21st Century skills

As a government school, the QSTSS curriculum goals align with the broad goals of the QNCF. The STEM focused curriculum at QSTSS concentrates in particular on the integrated development of the following set of 21st Century skills:



To foster the development of the 21st Century Skills, teachers and support staff will incorporate these skills into their teaching practices, curriculum, assessment, and professional development.

6.5.4. Transdisciplinary Assessment Projects

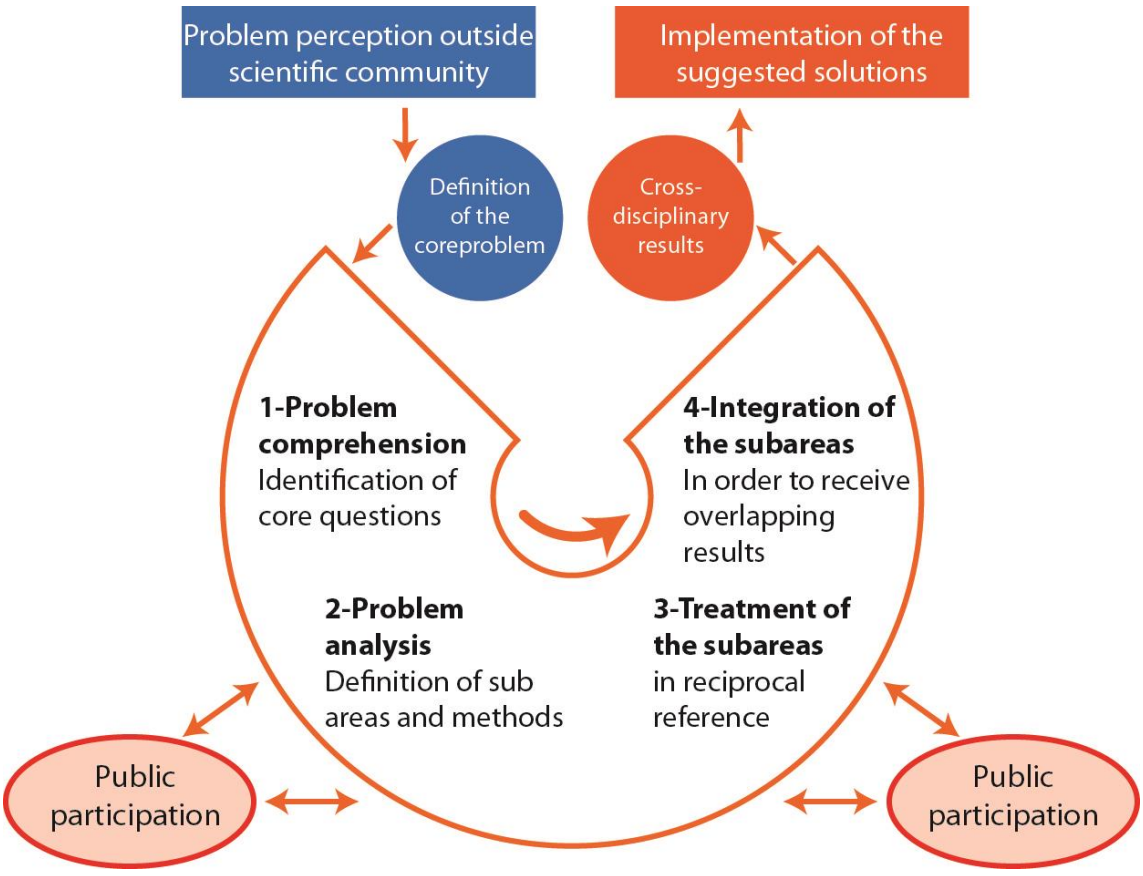
The transdisciplinary assessment projects are a component of the students' assessment policy across the subjects. The assessment projects are planned by teachers of the different subjects to assess the content knowledge, competencies, and the 21st century skills developed by students each semester across the subjects.

The transdisciplinary assessment projects are usually thematic and integrate 3 or more subjects and used for assessment purposes. Each semester, students will collaboratively work in small groups to submit two projects: one project integrates the STEM focused subjects including STEM, Mathematics, English, DT, &

ICT, and the second focuses on literature-focused subjects including Arabic language, social studies, and Islamic studies and it might include ICT & mathematics components.

Students are required to present and communicate these projects using various means including oral presentations, videos, posters, plays, etc. students' performance is assessed against specially developed rubrics.

The transdisciplinary assessment projects are project/problem-based learning experiences in which students utilize the 21st-century skills to solve real-world problems. Students are expected to follow a simplified model of problem solving strategy suggested shown below. (Source: Jaeger, J., & Scheringer, M. (1998). Transdisziplinarität: Problemorientierung ohne Methodenzwang. GAIA-Ecological Perspectives for Science and Society, 7(1), 10-25.)



Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

6.5.5. Learning Experiences in Specialist Laboratories

All students have frequent access to specialist laboratories, where they work with either teachers or engineers.

6.5.5.1. Digital Fabrications Laboratory

This facility allows students to learn about the principles of the invention, engineering design, manufacturing, and the development of products. The laboratory is managed by an experienced and qualified engineer who works directly with students.

In grades 9-10, this facility provides a stand-alone curriculum that is specially tailored for QSTSS (through the collaboration between the school and a local company known as ***ibTECHar***. The curriculum is based on the core STEM curriculum and provides activities, lesson plans, and learning objectives. Students attend scheduled lessons on a three-week cycle. Lessons are directed by the specialist engineer.

In addition, individual STEM teachers are able to negotiate time slots when they can bring classes of students to the laboratory in order to supplement their work in the classroom.

Teachers also negotiate time slots when they can work with small groups of students in relation to their role as project supervisors. Students must always be accompanied by a supervisor when attending the laboratory.

In grades 11-12 the Fabrications Laboratory supports students enrolled in the engineering stream. Students will attend the laboratory on a weekly basis. ***ibTECHar*** will work with the school management and the lab engineers to provide a comprehensive curriculum that utilizes projects as the starting point. An awareness of AP requirements will also be taken into consideration. In grade 11, three projects will be completed, while in grade 12, a more student-directed graduation project will be undertaken.

QSTSS is currently exploring the potential for FAB certification, linked with the Massachusetts Institute of technology.

The engineer liaises closely with the English department regarding areas of vocabulary that require further development.

6.5.5.2. Energy Laboratory

This facility allows students to learn about energy sources and solutions for renewable energy such as wind energy and solar energy. The laboratory is managed by an experienced and qualified engineer who works directly with students.

In grades 9-10, the curriculum is based on the use of specialist kits and their associated manuals. Links have been identified with the core STEM curriculum. Students attend scheduled lessons on a three-week cycle. Lessons are directed by the specialist engineer.

In addition, individual STEM teachers are able to negotiate time slots when they can bring classes of students to the laboratory in order to supplement their work in the classroom.

Teachers also negotiate time slots when they can work with small groups of students in relation to their role as project supervisors. Students must always be accompanied by a supervisor when attending the laboratory.

In grades 11-12, the Energy Laboratory supports students enrolled in the engineering stream. Students will attend the laboratory on a weekly basis. The lab engineers will provide a comprehensive curriculum that utilizes projects as the starting point. An awareness of AP requirements will also be taken into consideration. In grade 11, three projects will be completed, while in grade 12, a more student-directed graduation project will be undertaken.

The engineer liaises closely with the English department regarding areas of vocabulary that require further development.

6.5.5.3. Robotics & Automation Laboratory

This facility allows students to learn about the construction of robots and programming as well as the automation of processes. The laboratory is managed by an experienced and qualified engineer who works directly with students.

In grades 9-10 a curriculum has been developed which relates to the requirements of the STEM and maths curricula (content and sequence). The curriculum is largely stand-alone, based on the development of robotics skills and hardware (with programming and software covered in the ICT curriculum). Essential elements are not covered specifically in the core STEM curriculum are also addressed. In addition to the

basic course content, there is a focus on the development of directed projects, linked to various commercially available kits.

In addition, where required, individual STEM teachers can negotiate time slots when they can bring classes of students to the laboratory in order to supplement their work in the classroom.
Teachers are also able to negotiate time slots when they can work with small groups of students in relation to their role as project supervisors. Students must always be accompanied by a supervisor when attending the laboratory.

Many students are involved in There are also extra-curricular projects/competitions, where the expertise and equipment in the robotics laboratory may be required.

The engineer liaises closely with the English department regarding areas of vocabulary that require further development.

6.5.5.4. Biomedicine Laboratory

The curriculum applied in the Biomedical Laboratory at Qatar Science and Technology High School for Boys focuses on STEM orientation education through practical experiments in the fields of life sciences, biotechnology and physiology, where students through many experiments study the synthesis of genetic material and biotechnology applications such as PCR and gene transfer from one organism to another Genetic Transformation, Recombinant DNA technology, and applications of genetic engineering, along with experiments and applications associated with understanding the method of The work of the human body through the study of the anatomy and functions of the organs of the body, and the biometrics that are used in the diagnosis of diseases and the understanding of their symptoms, the curriculum of the Biomedical Laboratory aims to guide students to understand the applications of biotechnology and increase students' interest in medical university specialties.

6.5.5.5. Augmented Reality Laboratory

This facility allows students to use Z-Space devices to learn scientific concepts using 3D models and augmented reality technology. The Z-space devices are equipped with 3D lessons, learning modules, and virtual lab activities that can be used by STEM teachers and engineers to explain complex scientific concepts in an interactive and independent learning approach.

6.5.5.6. Virtual Reality Laboratory

This facility allows students to use virtual reality glasses to learn different concepts in an interactive way. The laboratory uses PICO headsets that are equipped with virtual lessons from science and Mathematics. The virtual modules are developed by "**Veative**" and are aligned with the NGSS, which allows STEM and Mathematics teachers to align these VR learning modules with their lessons and use the VR lab as an exciting and super-engaging learning tool.

6.5.5.7. Computer Science Laboratory

This fully equipped facility supports the integration of subjects and scientific research. The laboratory is primarily used by ICT/CS teachers epically for the delivery of physical computing and coding learning modules such as when teaching "Raspberry Pi", "Arduino", & "Machine learning".

6.5.5.8. Digital Library

This facility allows students to enhance their reading and research skills by providing access to a range of digital resources.

6.5.5.9. Science/STEM Laboratories

These facilities are equipped with specialized materials which provide an effective learning environment that enables students to keep abreast of the scientific and technological progress in all fields of STEM classes. The labs are divided into a Biology lab, a Physics lab, and a Chemistry lab. Each lab is equipped with advanced equipment, digital sensors, data loggers, and many other devices that allow students to apply the practical investigations of the STEM & AP courses.

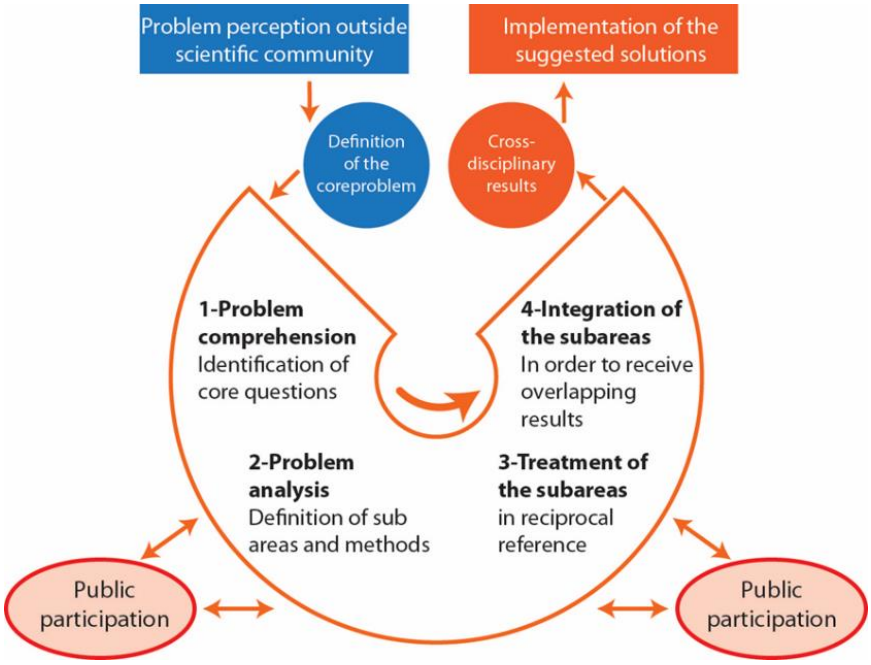
6.5.5.10. Language Laboratory

This facility is equipped with state-of-the-art computers and headsets which enable students to improve their English language skills through interactive and fun studies. The computers are prepared by SANAKO language learning software that allows teachers to personalize the English language experience and allows students to practice the different language skills in a self-paced way.

The Language lab is also used by Islamic studies and Arabic language teachers to teach topics and learning modules related to listening skills.

6.5.6. Individual Research Projects, supported by a supervisor.

All students are required to complete individual and group research projects and have frequent access to specialist laboratories, where they work with either teachers or engineers. The projects are STEM-oriented projects that are seeking to solve a challenging real-world problem using the simplified model of problem-solving strategy suggested shown below. (Source: Jaeger, J., & Scheringer, M. (1998). Transdisziplinarität: Problemorientierung ohne Methodenzwang. GAIA-Ecological Perspectives for Science and Society, 7(1), 10-25.)



6.5.7. Extra-curricular learning experiences, including university programs.

QSTSS arranges and promotes a wide range of extra-curricular learning experiences for its pupils. These include after-school clubs; local, national, and international competitions; visits by inspirational speakers; specially designed university programs; visits to museums; links with local businesses and industry; summer camps and specialist national events.

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

These programs also include partnerships and STEM-focused programs with major universities such as Qatar University, Texas A & M engineering college in Qatar, Weill Cornell Medical School in Qatar, Qatar Science Club, and many other in situations in Qatar that offer STEM-focused learning experiences to QSTSS students.

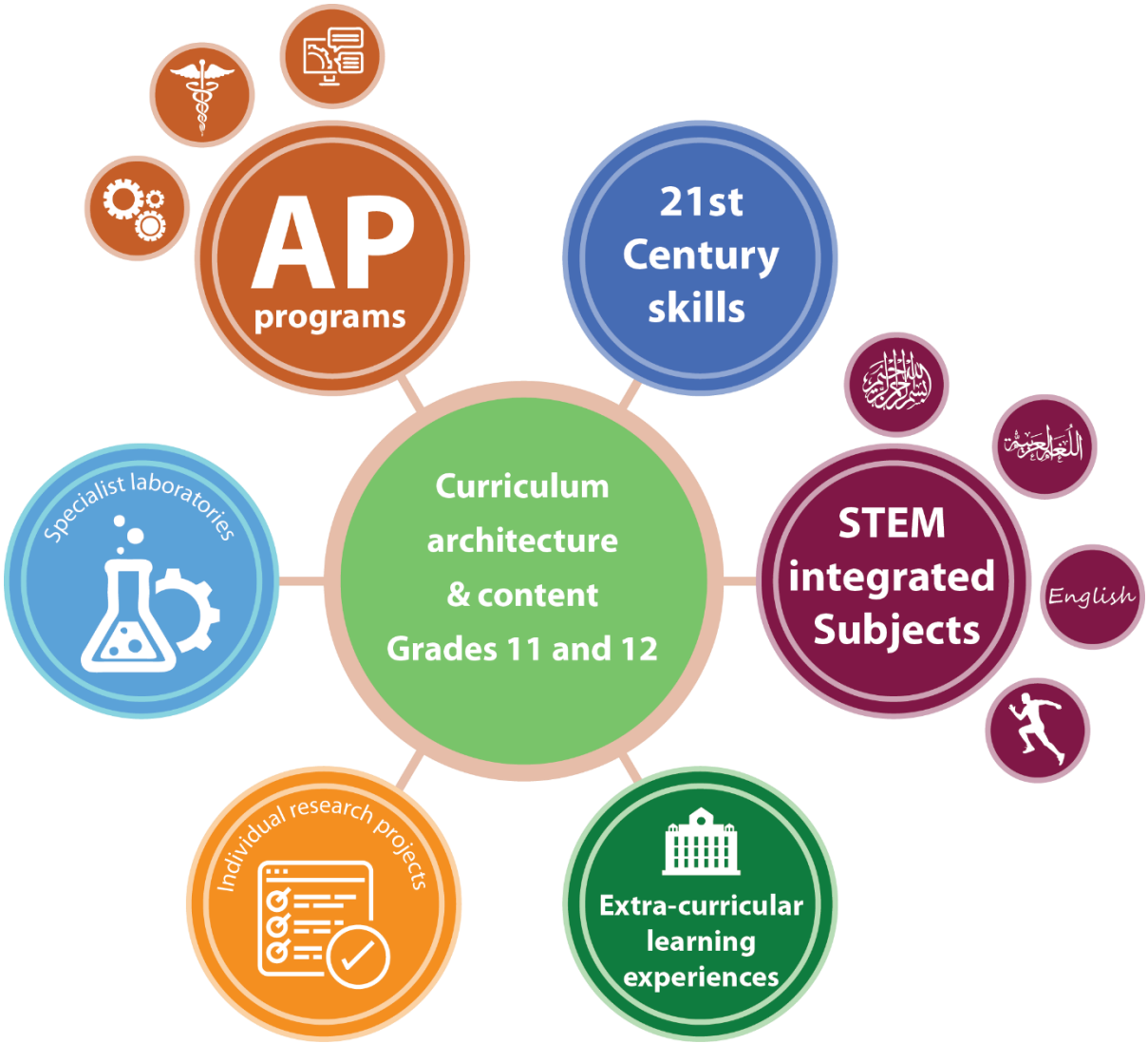
Examples of these programs include:

- Pre-engineering & digital fabrication program by Texas A & M
- Tabeeb (pre-medicine) program by Weill Cornell.
- Robotics & coding programs/competitions by Qatar University & North Atlantic College
- STEM-programs & research projects by Qatar Science Club
- Sponsored research projects supervised by Qatar Research Funds.
- Winter break & summer break training programs & camps in Qatar Petroleum company, and Hamad Hospital, etc.

6.6 Curriculum architecture and content. Grades 11 and 12.

In grades 11 and 12, greater emphasis is placed on preparing students for university entrance, with relevant Advanced Placement programmes providing the main curriculum. The further development of STEM related knowledge, skills and experiences will continue via dedicated time spent in specialist laboratories, researches & projects, and the university programs. The content and skills required in AP courses will have a direct influence on the laboratory-based STEM program.

To achieve the school's aims and objectives, the QSTSS curriculum framework comprises six main aspects in grades 11-12:



1. AP programs linked to one of three tracks (Engineering, Medical, Technology)
2. Integrated 21st Century skills and dispositions.
3. Arabic, English, Islamic Studies, P.E (integrated with STEM through the development of specific projects)
4. Learning experiences in specialist laboratories
5. Individual research projects, supported by a supervisor.
6. Extra-curricular learning experiences, including university programs.

6.6.1. AP Programmes

By the end of grade 10, based on their academic preferences and abilities, students choose to enrol in one of three tracks: Engineering, Medical, or Technology.

Students sit for the Scholastic Assessment Test (SAT) and IELTS test, in November of Year 11. Their performance will determine whether they pursue an AP in English or a modified program.

All AP programs will be delivered over two years, with examinations being taken in May of Grade 12. AP results are received in September.

Engineering Track	Medical Track	Technology Track
AP Calculus	AP Calculus	AP Calculus
AP Chemistry	AP Chemistry	AP Chemistry
AP Physics I	AP Biology	AP Computer Science A
AP Physics II	AP Physics 1	AP Physic 1
AP Computer Science Principals	AP Physics II	AP Physics II

In each track, students will follow the curriculum specifications authorized by the College Board for each AP subject.

Additional stand-alone documents provide more detail in relation to:

- Course description
- Course learning objectives
- Assessment strategies
- Course outline
- An identification of the alignment between the PE curriculum, the 21st Century skills, and the STEM curriculum.

6.6.2. Support and Integrated subjects:

As a government school, the QSTSS curriculum goals align with the broad goals of the QNCF.
As described above in grades 9 & 10 curriculum description, the STEM focused curriculum in grades 11 & 12 at QSTSS concentrates on:

1. **The development of the of 21st Century skills and dispositions.**
2. **the development of students' competencies in Arabic, English, Islamic Studies, P.E (integrated with STEM through the development of specific projects).**
3. **Learning experiences in specialist Laboratories.**
4. **Individual Research Projects, supported by a supervisor.**
5. **Extra-curricular learning experiences, including university programmes.**

7. Curriculum planning and delivery strategies

When planning and delivering the curriculum, our staff take into consideration the following guiding principles:

- The curriculum is planned and delivered in a collaborative, multidisciplinary, interdisciplinary, and transdisciplinary way, with the STEM curriculum being integrated within all other subjects.
- Student-directed learning approaches are at the heart of the QSTSS curriculum.
- The design and delivery of the curriculum encourages students to engage in discovery, research, and enquiry.
- An enquiry-based and problem-solving-based approach is employed in both the design and delivery of the curriculum.
- The design and delivery of the curriculum supports the goal of finding solutions to authentic local, national, and international challenges and problems.
- The curriculum encourages hands-on and experiential learning.
- The design and delivery of the curriculum encourages design-based learning.
- The integration of technology into the curriculum is a fundamental feature of design and delivery.
- The design and delivery of the curriculum encourages the development and application of 21st Century skills.
- Activities are designed and delivered in a way that encourages students to work cooperatively and collaboratively and to value the contribution of their peers.

- The design and delivery of the curriculum encourages the development of communication skills and both interdependence and independence.

Please see the QSTSS Teaching and Learning policy for more detail.

8. Student Assessment

We believe that student assessment is an integral part of the educational process, providing data and feedback that facilitates effective continuity and progression in relation to the student learning experience. Our student assessment arrangements provide us with information about each student's progress and attainment levels, identifying what they know, understand, and can do.

QSTSS utilizes a range of internal and external student assessment procedures and tools as part of its formative, summative and diagnostic assessment approaches. Please see the QSTSS Student Assessment Policy and subject-specific curriculum documents for more information.

An analysis of the data we gather allows us to review all aspects of the student learning experience, including:

- Curriculum content.
- Curriculum organisation.
- Curriculum delivery strategies e.g., the teaching and learning process, differentiation (content, process, outcomes, environment), as well as the individualisation and personalization of the learning experience.

The strategies we have adopted for gathering, collating, recording, and reporting data gained as part of the student assessment process are designed to reflect and support the overall vision and mission of the school.

Please see the QSTSS Students Assessment policy for more detail.

9. Induction and continuing professional development for staff.

A comprehensive professional development programme is provided for all staff members. Newly appointed teachers are involved in an induction programme, where they are introduced to the curriculum (the architecture, the content, delivery strategies, and assessment procedures). Following induction, all teachers are engaged in professional development opportunities which are both subject-specific and generic in nature. Teachers are encouraged to engage in small-scale action research projects, linked to all aspects of the curriculum.

Please see the Professional Development policy for more details.

10. The Quality Assurance process: Curriculum Review

Our quality assurance approach requires a systematic review of all aspects of the curriculum to maintain and improve its quality, balance, coherence and relevance. Our over-riding objective is to improve the quality of the student learning experience, with the goal of promoting the best possible learning experience and outcomes for our students.

As part of our review process, a named member of staff is responsible for coordinating an evaluation of the effectiveness of the QSTSS curriculum on a regular basis. This is a collaborative activity (involving leadership, staff, and other stakeholders). Judgments are made about the quality of the curriculum through reference to an agreed set of quality indicators. **See appendix One**.

The STEM element of the curriculum at QSTSS is in line with the international standards identified in documents such as: The European STEM Schools Report: Key Elements and Criteria Article - January 2018 https://www.researchgate.net/publication/332189909
and the STEM Certification standards and indicators developed by Cognia: https://www.advanc-ed.org/sites/default/files/documents/state-resources/STEM-Certification-Overview.pdf

The QSTSS indicators are based on these international standards and form the basis of the review. The review produces a set of jointly agreed final recommendations, which inform the development of the School Development Plan.

Please see the Quality Assurance policy for more details.

Appendix One. Quality Indicators: The STEM Curriculum

1. Curriculum Rationale

1.1. A clear identification of what constitutes a STEM curriculum is provided to all stakeholders.

1.2. Vision and mission statements reflect local, national, regional, and international aspirations and priorities, as well as reflecting STEM education objectives.

1.3. The curriculum aims to prepare students for successful undergraduate study and entry into high skilled STEM related employment opportunities.

1.4. The school identifies a clear set of goals that reflect both STEM objectives and Islamic / national / ethical values.

2. Students

2.1. The STEM school supports non-traditional student participation through outreach to groups often underrepresented in STEM program areas. **(Cognia ST1.1.)**

3. Curriculum Content

3.1. The curriculum identifies the key 21st Century skills, STEM skills and higher order thinking skills it wishes to develop with students and has strategies in place to develop these with all students.

3.2. The curriculum identifies the STEM related characteristics it wishes to develop with students.

3.3. The curriculum is focused on the integrated study of science, technology, engineering and mathematics.

3.4. The curriculum provides a balanced educational experience that develops appropriate levels of skills and knowledge in relation to ICT, Design and Technology, Arabic, English, Social Studies, Islamic Studies, and PE

4. Curriculum Architecture

4.1. The curriculum is based on sets of curriculum standards / expected learning outcomes in relation to STEM and additional subjects and skills. These provide the basis for an integrated approach as exemplified in interdisciplinary schemes of work and learning experiences

4.2. The curriculum architecture identifies the interrelationship between STEM specific subjects, additional subjects, cross-curricular skills, learning goals, and Learner Profile characteristics

4.3. A comprehensive description of the curriculum architecture is provided within a detailed curriculum framework

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

5.Curriculum Planning

5.1. STEM educators collaborate as an interdisciplinary team to plan, implement, and improve integrated STEM learning experiences. (ST1.7.)

5.2. Projects are specially designed so as to realise intended learning outcomes in an integrated and interdisciplinary / transdisciplinary way

6.Instruction / Teaching Approach

6.1. Students are empowered to personalize and self-direct their STEM learning experiences supported by STEM educators who facilitate their learning. (ST1.3.)

6.2. Teachers employ instructional approaches that address the different learning needs, interests and cultural backgrounds of students.

6.3. Students work independently and collaboratively in an inquiry-based learning environment that encourages finding creative solutions to authentic and complex problems. (ST1.2.)

6.4. The school follows an Inquiry-Based Science Education (IBSE) approach, in which questions, problems and scenarios are presented to students, including case studies, fieldwork, investigations or research projects, etc.

6.5. Problem- and Project-Based learning (PBL) approaches are employed. The school encourages student-centred pedagogy in which students learn about subjects by solving open-ended problems and/or projects, either individually or collaboratively.

6.6. The interdisciplinary problem-based curriculum includes a focus on real-world applications. (ST1.6.)

6.7. The development of research skills is embedded in the curriculum, in particular the capacity to initiate and carry out original small-scale action research projects.

7. Student Assessment

7.1. Student assessment activities are based on reference to agreed curriculum standards / learning outcomes.

7.2. Students are actively involved in the assessment process in the form of self and peer assessment, with reference to learning outcomes and rubrics.

7.3. Students demonstrate their learning through performance-based assessments and express their conclusions through elaborated explanations of their thinking (ST1.5.).

7.4. A continuous assessment approach is employed (baseline, diagnostic, formative, summative)

7.5. Assessment typology is personalised and framed to demonstrate whether pupils have met specific educational goals, according to their personal development.
7.6. A competency-based assessment approach is employed where appropriate.

8. Professional Competence and Development

8.1. The school employs highly qualified and experienced professionals, whose specialisations are in STEM education or STEM-related subject areas.
8.2. All managers, teachers, engineers, lab. technicians and support staff are provided with a comprehensive programme of professional development (induction and CDP)
8.3. STEM teachers and leaders participate in a continuous program of STEM-specific professional learning. (ST1.9.)
8.4. All teaching staff are encouraged to engage in a regular programme of small-scale action research projects.
8.5. The evaluation of teacher and support staff effectiveness is based on the quality of the student learning experience.

9. Connections with the Wider Community

9.1. STEM learning outcomes demonstrate students' STEM literacy necessary for the next level of STEM learning and for postsecondary and workforce readiness. (ST1.8.)
9.2. Community, postsecondary, business/industry partners, and/or families actively support and are engaged with teachers and students in the STEM program. (ST1.10)
9.3. Students are supported in their STEM learning through adult-world connections and extended day opportunities. (ST1.11.)

10. Infrastructure and Technology

10.1. Students use technology resources to conduct research, demonstrate creative and critical thinking, and communicate and work collaboratively. (ST1.4.)
10.2. Specially equipped laboratories are provided which support the introduction and reinforcement of new concepts and skills and which allow for the practical application of skills and knowledge in order to solve authentic problems and challenges
10.3. Technology applications are an integral part of the teaching and learning process.

11. Resources

11.1. Curriculum resources are appropriate and of the highest quality, and support the delivery of a STEM curriculum.

11.2. The learning experience is enhanced by the development of close links with external partners (higher education, business, industry, the local community) and access to their resources.

12. Quality Assurance

12.1. There is a school policy and system in place that facilitates the evaluation of school effectiveness in relation to the curriculum.

12.2. A named person is responsible for managing the quality assurance (QA) process in relation to the curriculum.

12.3. The policy identifies the criteria against which judgments about the quality of the curriculum can be made.

12.4. A regular cycle of internal curriculum review and revision is in operation.

12.5. A periodic cycle of external curriculum review is in operation.

12.6. Insights gained form the QA process inform the objectives identified in the School Development Plan.

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

The Teaching of STEM and the QSTSS school

Dr. Thomas Hsu

Lead author, Fundamental Science and Engineering

Why do we teach science and mathematics in high school education? Is the purpose to prepare 0.1% of students whom might become research scientists? Or, is the purpose to prepare 99.9% of students to succeed in an increasingly technical working world? How has technology changed teaching and learning? For better? For worse?

My purpose in this paper is to provide one answer to these complex questions and discuss the guiding principles and thinking behind the STEM curriculum for the QSTSS school. First, I would like to say what the curriculum is *not*. The *Fundamentals of Science and Engineering* curriculum is not an after- school engineering enrichment program. The first and last letters in STEM are the initials for Science and Mathematics. Qatar is leading the world with QSTSS in the synthesis of core content in science and mathematics with engaging, practical, and innovative content in technology and engineering. Why the emphasis on science and mathematics? Because, it is a pragmatic reality that our QSTSS graduates must demonstrate mastery of science and mathematics to be accepted into the next phase of their professional education. This is half of the answer to the first three questions.

To understand our choices in developing the QSTSS curriculum it is crucial to understand the goals and strategies that were defined by the Ministry of Education. Think about our challenge of preparing young people for success in a rapidly changing future world that does not yet exist. Students are diverse and their future world offers a diversity of paths to success. The QSTSS school was purpose-built to address one important success path - that of preparing students for careers in engineering, technology, medicine, and other STEM fields. The Ministry of Education wisely defined a goal that is both visionary and pragmatic.

Goal: Every graduate of QSTSS who wishes to pursue a career in STEM will be accepted by an excellent university of engineering in the United States - such as Texas A&M or Cornell.

Strategies are large-scale, overview plans that define broadly how the goal will be met. For example, if the goal is to reduce the incidence of a disease one strategy would be to educate people on how to recognize and avoid risks, a second strategy might be to educate doctors and hospitals on recognizing the disease, and a third strategy might be to provide incentives to researchers and pharmaceutical companies to find and produce appropriate medicines. Like all good plans, The Ministry of Education plan for QSTSS specified multiple and overlapping strategies.

QDB بنك قطر للتنمية QATAR DEVELOPMENT BANK ExxonMobil STEM
الرؤية: تمكين الطلبة من مهارات القرن الواحد والعشرين، وإعدادهم للمساهمة الفاعلة في بناء الاقتصاد الوطني القائم على المعرفة والتطور العلمي والتكنولوجي.
Vision : Empowering students to develop the 21st century skills and preparing them to contribute effectively to building a national economy that relies on knowledge along with scientific and technological advancements.
Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa

Strategies for QSTSS

1. Attract more and better students to STEM fields. Strategy: Include new and engaging technologies such as interactive curriculum, robotics, and virtual reality in everyday classroom use and make STEM the focus of the school in all aspects of curriculum

2. The vast majority of accepted students at the target universities have taken two or more AP courses such as AP calculus, AP physics, AP chemistry and AP biology. *Strategy: QSTSS students will take 4 AP courses in the junior and senior year.*

3. For the past decade the majority of high school graduates accepted by the target universities have been educated in accordance with the NGSS science standards which incorporate engineering processes as well as science content. *Strategy: design a new grade 9 and grade 10 STEM curriculum to meet the NGSS Science standards and simultaneously prepare students for AP courses while integrating engineering and technology consistent with the mission of the school.*

4. All students should be able to pass the Qatar national exams in science and mathematics. *Strategy: any new curriculum should be designed or selected to meet the Qatar national standards for science and mathematics.*

5. All of the entrance tests used by the target universities, such as the SAT or ACT, are in the English language. Strategy: Science and mathematics instruction at QSTSS will be in English.

6. Even students with excellent grades are often not accepted because all applicants to the target universities have excellent grades. Something additional is required to demonstrate special interest in STEM careers. Strategy: The engineering lab and technology lab facilities and faculty of the school will ensure that QSTSS students will complete multiple design projects and research projects in addition to more traditional academic work.

Designing the curriculum

The QSTSS curriculum for grades 9 and 10 had to be *primarily a science and mathematics curriculum*
with a technology and engineering integration wherever possible. This was necessary because:

1. the curriculum had to prepare QSTSS students for rigorous AP courses in grade 11 and 12 which were pure science or mathematics (non-STEM),
2. the curriculum had to meet the NGSS science standards, and
3. the curriculum had to prepare students to scoring highly in college entrance tests such as the SAT or ACT which are not STEM.

The science topics the new curriculum had to cover were defined by the NGSS, the Qatar National Standards, and the topic areas covered by the AP courses. The mathematics topics were defined by the preparation for AP calculus, and the SAT exam. After the first iteration of the curriculum design it was decided that the integrated STEM mathematics were not sufficient for calculus/SAT preparation. The Mathematics specialists advised we

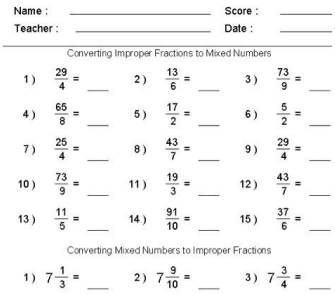
add an innovative curriculum from Haese to teach a three-period-per- week math specialty class in parallel with the integrated STEM course.

While meeting the science content requirements, the QSTSS curriculum, *Fundamentals of Science and Engineering* is still not a traditional science program. Our design incorporated the concept of STEM deeply into the curriculum in five different ways. None of these five ways are part of a typical high school textbook.

STEM is a technique for teaching and learning.

There are many ways to teach any element of content. Consider the mathematics of fractions and ratios. These topics are traditionally taught with lectures and worksheets such as shown on the left below. The STEM approach uses a real engineering example - gears - to teach the same concept. Students create, analyze, and design gear machines to learn fractions and ratios by application.

Traditional lesson on fractions and ratios



Name : _____ Score : _____
Teacher : _____ Date : _____

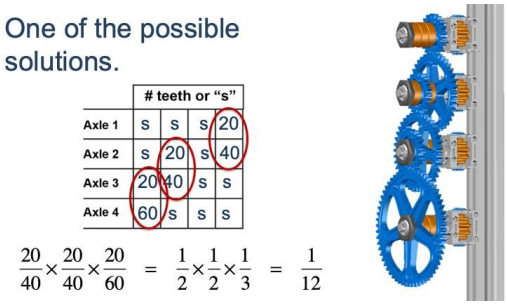
Converting Improper Fractions to Mixed Numbers

1) $\frac{29}{4}$ = ___ 2) $\frac{13}{6}$ = ___ 3) $\frac{73}{9}$ = ___
4) $\frac{65}{8}$ = ___ 5) $\frac{17}{2}$ = ___ 6) $\frac{5}{2}$ = ___
7) $\frac{25}{4}$ = ___ 8) $\frac{43}{7}$ = ___ 9) $\frac{29}{4}$ = ___
10) $\frac{73}{9}$ = ___ 11) $\frac{19}{3}$ = ___ 12) $\frac{43}{7}$ = ___
13) $\frac{11}{5}$ = ___ 14) $\frac{91}{10}$ = ___ 15) $\frac{37}{6}$ = ___

Converting Mixed Numbers to Improper Fractions

1) $7\frac{1}{3}$ = ___ 2) $7\frac{9}{10}$ = ___ 3) $7\frac{3}{4}$ = ___

STEM lesson on fractions and ratios

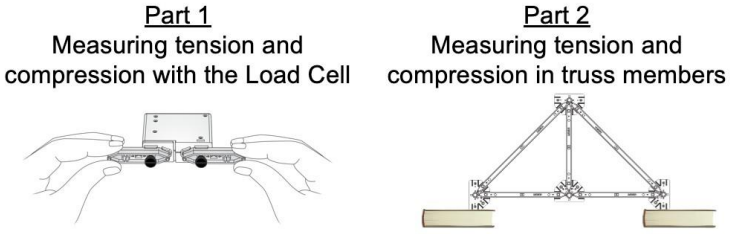


One of the possible solutions.

	# teeth or "s"			
Axle 1	s	s	s	20
Axle 2	s	20	s	40
Axle 3	20	40	s	s
Axle 4	60	s	s	s

$$\frac{20}{40}\times\frac{20}{40}\times\frac{20}{60} = \frac{1}{2}\times\frac{1}{2}\times\frac{1}{3} = \frac{1}{12}$$

Another example is the concept of force, Force is a core idea in physics *and engineering.* Rather than take the traditional physics approach, we developed both the text and the hands-on learning activities around modern engineering tools such as a load cell (Chapter 7) and the construction of a truss bridge.



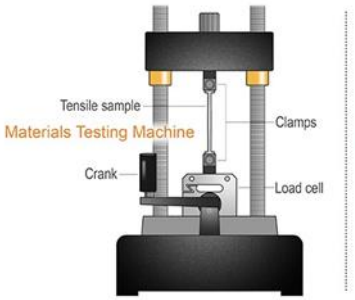
Part 1
Measuring tension and compression with the Load Cell

Part 2
Measuring tension and compression in truss members

The load cell allows students to immediately experience the relationship between a force - tension or compression - and the positive or negative value that describes that force. Pushing on the load cell creates a compression or negative force. Pulling creates a tension, or positive force. The human brain is a master of visual processing. Visualizing abstract ideas is a powerful way to create real and lasting understanding, a central goal of teaching and learning.

STEM is a body of knowledge and skills broader than pure science or mathematics

In a traditional physics course the teaching of force typically ends when students demonstrating they can solve paper and pencil equilibrium problems. In engineering the idea of force is extended to describe the strength of materials. The single force becomes the distributed stress that causes solid materials to deform and ultimately break. Students use a tensile tester (Chapter 8, grade 9) to examine the failure of materials and are introduced to some basic principles of mechanical design. Consider that solving a physics problem means finding the right answer. You typically do not care about the wrong answers. Designing a bridge to stand up cannot be done in the same way. Engineers do not design a bridge to stand up.
Engineers design a bridge not to fall down. You must consider all the ways the bridge can fail, then choose materials and design so it will not fail in each possible way. The consideration of failure is an explicit part of all engineering design. This is a STEM skill that extends pure knowledge of science into real and practical applications.



Tensile strength of common materials

Material	Tensile Strength (MPa)
Glass	33
HDPE Plastic	37
Wood	40
Bone	130
Aluminum	300
Steel	800

To explain the behavior of a bridge requires that many possible choices be advanced, discussed, modified, and evaluated. This is one of the important ways in which creativity is crucial to science and engineering. Creativity is much more than just creating literature, music, and art. Creativity is the source of ideas and potential explanations. Creativity is how we imagine "what if" scenarios to evaluate possible solutions.

STEM provides a schema for deciding what to teach and what not to teach

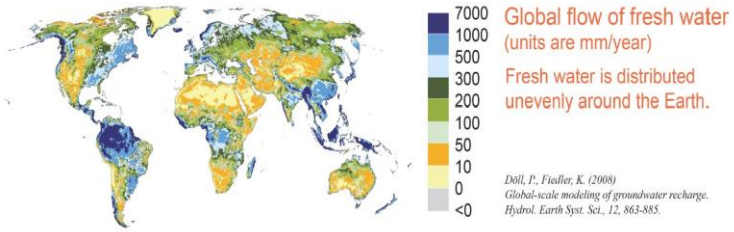
Even within the topics prescribed by the standards there is far, far more scientific and mathematical knowledge than can be effectively learned in the limited amount of teaching time in a school year. Choices must be made on what to teach to be learned, what to mention briefly for completeness, and what to leave out. The Technology and Engineering aspect of STEM provides a framework in which to make these choices instead of leaving it to "how far in the book did I get by the end of the year."

1. Is this concept only useful to research scientists or is there broader application in today's engineering or technology? For example, the physics concept of electron beams in a cathode ray tube is no longer useful in technology so we did not teach this.
2. Can this concept only be read about or can the concept be explored by the

student in a direct experience or through interactive simulation?

3. Is there an aspect of this concept that is directly applicable to current or future engineering or technologies, and specifically to engineering and technologies relevant to Qatar?

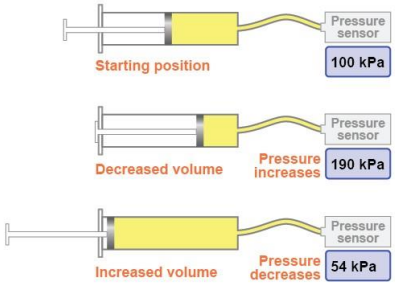
We continually asked ourselves these questions about the content of the QSTSS curriculum. As an example, when teaching the idea of biomes we made a focus on the very unequal distribution of fresh water in the world. Many aspects of biomes and climate are important but this particular aspect has critical implications for human engineering and technology (chapter 29).

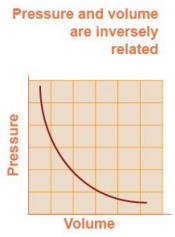


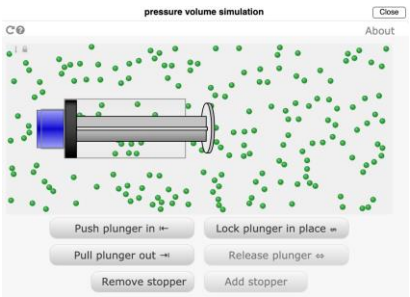
STEM means using modern tools such as sensors and spreadsheets

The famous Nobel laureate Richard Feynmann was once asked if all scientific knowledge was lost except for one fact - what fact would he preserve? His answer was the existence of atoms. Every aspect of our experience with the world of matter ultimately comes from the behavior of atoms. The solidity of concrete, the action of medicines, the ability of electricity to flow in wires, even the sound wave carrying my voice to you come from atoms. But atoms are invisible.

The lesson (16.4) on gas pressure in *Fundamentals of Science and Engineering* uses both a pressure sensor to measure in real-time and an interactive simulation that makes very clear how pressure is created by the motion of atoms. Students press the plunger on a syringe containing a trapped volume of air. The pressure sensor provides a real-time measurement of the pressure that the students can both feel directly and see as a numerical value.

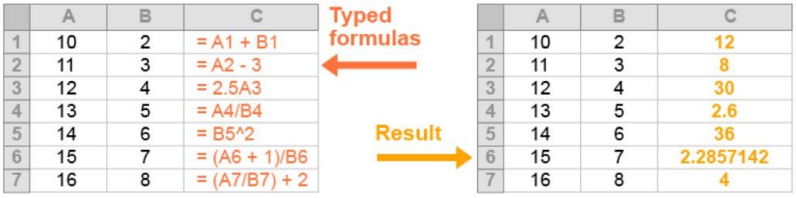






Technology allows the interactive simulation to make the atoms large and visible. Students simulate the same experiment with the syringe but, now they can see the atoms in the compressed air madly banging back against the plunger and making the force they feel.

The entirety of Chapter 4 is on the use of spreadsheets. Spreadsheets are the indispensable mathematical tool used by virtually all scientists and engineers of all disciplines. The QSTSS curriculum teachings students to build analytical models of simple equations such as the Body Mass Index as well as more complex models.



	A	B	C
1	10	2	= A1 + B1
2	11	3	= A2 - 3
3	12	4	= 2.5A3
4	13	5	= A4/B4
5	14	6	= B5^2
6	15	7	= (A6 + 1)/B6
7	16	8	= (A7/B7) + 2

	A	B	C
1	10	2	12
2	11	3	8
3	12	4	30
4	13	5	2.6
5	14	6	36
6	15	7	2.2857142
7	16	8	4

STEM provides a contextual relevance for science content

Many practical applications use the same concept as taught in a science class but with different units of measurement. For example, the chemistry concept of concentration is typically taught with units of molarity or percent mass. In lesson 21.3, we teach the same concept with units of parts per million (ppm) or parts per billion (ppb). The solved example problem shows how pollution standards are applied to the lead content of drinking water in parts per billion.

Closing

The STEM initiative is neither the first, or last, to help educators keep the practice of teaching aligned with useful and productive learning. To put this in perspective, consider other areas of innovation. A mechanic from a hundred years ago looking under the hood of a modern car would be clueless about most of what he found there. Yet the classrooms of most schools today look eerily similar to the classrooms of the last century. Sure, there may be digital projectors instead of chalkboards. But, most students still sit in rows listening, watching, and solving pencil-and-paper problems.

Our vision for the new QSTSS textbook was different. The first and most important of our guiding ideas was that students should learn by directly experiencing science, engineering, and technology as much as possible. More than 100 interactive simulations and equations help students visualize and actively experiment with science and mathematics concepts in more effective ways than could be done with a traditional printed book. When I taught the plasma physics laboratory course at MIT in the late 1980's my students spent only 25% of time in a classroom and the other 75% in the lab doing science instead of reading about it. I am happy to see that the students and teachers at the QSTSS school are also spending most of their time in the labs.

In closing, let me repeat a few key points.

1. The current version of the QSTSS curriculum is primarily a science program that incorporates STEM content, tools and techniques to teach the science that must be covered to meet the NGSS, and prepare students for AP courses and the Qatar national exams in science.
2. The quantity of knowledge and skills our students need to succeed in the 21st century is vastly greater than it was even fifty years ago. The STEM perspective provides a scheme for prioritizing what we teach.
3. Even difficult ideas such as the molecular explanation of pressure are learnable if taught in a STEM way.

4. The requirements of 21st century learning are so much greater; the teaching tools need to be far more effective than a paper textbook and a pencil.

Dr. Tom Hsu

Tel : +974 40362870 | Fax : +974 40362894 | P.O.Box: 82035 | Email: qsst.boys@edu.gov.qa