TRENDS AND ISSUES IN TECHNOLOGY EDUCATION IN THE USA:
Lessons for the Caribbean

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This paper traces various developments in technology education at the turn of the 21st century in the USA. It begins by highlighting issues that were being discussed in the 1990s among the technology education community, and the efforts by the science and engineering communities to help shape the content of technology education. The efforts of the International Technology Education Association (ITEA) to create standards for technological literacy in 2000 and supporting standards for assessment and professional development in 2003 are discussed. The recommendations from the report *Technically Speaking* and the impact it had in defining how a technologically literate person is characterized are also presented. This paper also examines the work of the National Center for Engineering and Technology Education (NCETE) from 2005–2012 in spearheading an understanding of how engineering design can be infused in schools, and also how students learn engineering design. The role of pre-engineering curricula in STEM education is examined, and the various curricula that are being used in technology education classrooms since the publication of the *Standards for Technological Literacy* are also traced. Finally, lessons that the Caribbean can learn from the recent evolution of technology education in the USA are discussed.

Introduction

The past decades have seen the world's economy increasingly being driven by technological innovation and an increasing percentage of jobs requiring advanced technological skills. Technology's power as an economic and social force occupied public discussions in many advanced and emerging economies. These conversations have led in some cases to the restructuring of national curricula to address creative and critical thinking, and technological knowledge and processes that are necessary for a 21st century economy. The role of technology as an economic driver, its integrative nature as a knowledge domain, and its ubiquitous presence in the social strata and systems of society have led to intensified

efforts in many countries to ensure that the populace is more informed about technology.

Technology is not just the mere artifact, but also involves the knowledge and processes necessary to create and operate these artifacts or products. So technology also includes the engineering know-how and design, manufacturing expertise, technical skills, and the people and organized structure required to produce and use artifacts. Technology by its nature is multi-domain, and curricular endeavours to teach it through the separation of science and mathematics are artificial; serving only the purpose of school organization rather than supporting the dynamic and creative learning needs of students and the practical demands of society (Education for Engineering, 2013). This understanding of technology has gradually influenced much of the school reforms in math and science over the years (Herschbach, 1997). National curriculum endeavours, particularly in the 1990s and thereafter, have seen a shift away from approaching technology education through "different technically oriented syllabi and piecemeal inclusion of technological aspects within science and social sciences" (Compton, 2009, p. 24), to national curricula and standards that address technological literacy. The philosophy is to address technology as a "coherent learning area" with distinct "theoretical underpinning and expectations" for teaching and learning (Compton, 2009, p. 24). The need for technological literacy as an educational outcome for all students is a common consensus in many countries.

Compton (2009) argued that technological literacy serves to enhance democratically aligned educational goals. Through this form of general education, a base is provided for students to understand their existence and potential future role in a wider technological world. National curricula in England, Wales, New Zealand, and Australia are moving away from being prescriptive, to providing strands or frameworks for technology education, with related standards for learning and assessment at all grade levels (see Australian Curriculum, Assessment and Reporting Authority [ACARA]; Compton, 2009; Education for Engineering, 2013; Jones, 2007). Technology education is being viewed as an essential form of literacy for the 21st century, comparable to mathematics, science, and reading. In the USA, after changing its name from *industrial arts* to *technology education* in the 1980s, the technology education field became inextricably enmeshed in the "legacy of industrial arts and its struggle to find curricular direction within the context of competing progressive, essentialist, and technocratic ideas concerning education" (Herschbach, 1997, p. 25).

This article describes significant developments in terms of standards, emerging pedagogical issues, research addressing learning and professional development in technology education, and general practices in K-12 classrooms, as the field attempts to redefine itself by addressing technological literacy development. It traces various developments in technology education at the turn of the 21st century in the USA. The article begins by highlighting issues that were being discussed in the 1990s among the technology education community and efforts by the science and engineering communities to help shape the content of technology education. The efforts of the International Technology Education Association (ITEA) to create standards for technological literacy in 2000 and supporting standards for assessment and professional development in 2003 are discussed. The recommendations from the report *Technically Speaking* and the impact it had in defining how a technologically literate person is characterized are also presented. This paper also examines the work of the National Center for Engineering and Technology Education (NCETE) from 2005–2012 in spearheading an understanding of how engineering design can be infused in schools, and also how students learn engineering design. The role of pre-engineering curricula in STEM education and the various curricula that are being used in technology education classrooms since the publication of the *Standards for Technological Literacy: Content for the Study of Technology* (STL) are also traced. Finally, lessons that the Caribbean can learn from the recent evolution of technology education in the USA are discussed.

A Time for Introspection and Action

Over the years, technology has progressively played an integral role in the lives of Americans. While America's prominence can be attributed to its technological hegemony—particularly in military, business, and industry—at no time in history has technology been so user-friendly and interwoven into the fabric of the day-to-day life of ordinary citizens. Yet, at the latter part of the 20th century, when the information technology phenomenon was rapidly spreading, several stakeholders in technology, engineering, mathematics, and science realized that even as technology become a part of Americans' way of life, it had receded from view; in effect it had become "invisible" (Pearson, Young, National Academy of Engineering [NAE], & National Research Council [NRC], 2002, p. 1). Americans were poorly equipped to address the challenges technology poses or the problems it could solve. While the use of technology was increasing among ordinary citizens, there was no sign of a corresponding

improvement in their ability to deal with issues relating to technology (Pearson et al., 2002). Technology is normally seen in a narrow perspective; in terms of its artifacts such as cell phones and computers. Usually, it is not seen in terms of the knowledge and processes necessary to create and operate a wide range of artifacts; the infrastructure necessary for design, operation, and repair; and the organization of personnel necessary to produce these artifacts. What was required was a technologically literate society.

Stirred by the growing need for technological literacy for all citizens, the ITEA (now the International Technology and Engineering Educators Association [ITEEA]) initiated the "Technology for All Americans Project" in 1994, with the aim of providing a formal structure for technology education programmes across the country (Dugger, 2002). The initiative was triggered not only by social, political, and economic discussions, but also out of the struggle by the Technology Education profession to clearly convey its educational purpose in terms that relate to the issues of the day, and to align its programming more closely to the major curriculum perspectives articulated in discussions over the purpose, substance, and form that public education should take (Herschbach, 1997).

The project was three-phased and would culminate in standards that address the learning and assessment of technology education for grades K-12. The project commenced in 1994 and was funded by the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). According to Dugger (2002, pp. 96-97), the major deliverables (paraphrased) were:

- **Phase I—Technology for All Americans: A Rationale and Structure for the Study of Technology (RSST, 1994–1996)**. *RSST* established the fact that technological literacy is much more than just knowledge about computers and their application. It defines technology as *human innovation in action* and creates a vision where each citizen should have a degree of knowledge about the nature, behavior, power, and consequences of technology from a broad perspective.

- **Phase II—Standards for Technological Literacy: Content for the Study of Technology (STL 1996–2000).** STL was released at the ITEA conference in Salt Lake City in April 2000. In the review and consensus-building process, more than 4,000 people contributed to the improvement of the document as it was developed and refined, including educators, administrators, and experts from the fields of science, mathematics, and engineering, among others. STL is

endorsed by both the National Research Council and the National Academy of Engineering.

- **Phase III—Companion Standards to *STL* (2000–2003).** The final phase of the Technology for All Americans Project is to develop a companion document for *STL* articulating the standards for assessment, professional development, and programs. The assessment standards are designed to address specific goals and purposes and define who to test, when to test, and what kind of test to use. Professional development standards describe the attributes and skills that teachers should acquire as the result of inservice ongoing education. They apply to every teacher in the schools who is teaching any aspect of technology. And finally, program standards address the totality of the school program across grade levels.

Issues and Concerns Facing the Field

The years leading up to this national initiative were a time for deep reflection on the future of technology education in the USA. Much had happened in the field since its name change from industrial arts to technology education in the 1980s. According to LaPorte (2002), the name change was followed by a flurry of efforts at all levels to articulate just what technology education is and how it might be put into teachable terms. Philosophical and practical arguments ensued in all sectors of the field. Scholarly articles and seminal work at the time echoed the essence of these discussions.

In a study describing present and future critical issues and problems facing the technology education profession, Wicklein (1993) identified curriculum development approach, curriculum development paradigms, lack of consensus on curriculum content, and non-unified curriculum as some critical areas of concern. Another critical area of concern was the need for clarity in what constituted the knowledge base for technology education. Such a formal knowledge base would help in establishing needed precedents for future development within the field. A final critical issue was the concept of interdisciplinary approaches to the delivery of technology education content. The need to integrate technology education with other disciplines was viewed as an essential element for the success of the field. The issues identified in Wicklein's study resonate with the challenges that were inherent to technology education, because of what some viewed as the lack of formal structure; as is the case in other disciplines such as mathematics, economics, or physics (see Frey, 1989; Herschbach, 1995). In addition, technology is interdisciplinary in its use of knowledge, and some opined that "the

concept of technology does not lend itself well to a separate subject curriculum orientation," making it difficult "to pin down a definitive structure underlying technology in terms amenable to curriculum development patterned after the academic rationale" (Herschbach, 1997, p. 21).

Technology education researchers have been consistent in emphasizing the non-utilitarian, social dimensions of technology, with many scholarly articles devoted to discussing how technology impacts social structure and conditions; how people live and work; and also how it extends human potential, shape values, and affects the environment (Herschbach, 1997). Custer (1995) addressed the dimensions of technology education. He described technology education as having:

- a human dimension, in that it is a purposeful activity conceived by inventors and planners and can be promoted by entrepreneurs;
- a social dimension, in that it is used and implemented by society, it has effects on society, and it is influenced by value judgments;
- a process dimension, in that it involves doing, making, and implementing with materials; involves design practice and is used to solve problems; is subject to the laws of nature, and may be enhanced by discoveries in science or may often precede science;
- a contextual dimension, in that it is conducted within contexts and constraints;
- and a product dimension, in that it leads to the development of products or artifacts.

Providing a sketch of research in technology education during that period, Zuga (1994) explained that the research base was narrowly defined and inwardly focused, addressing mainly the curriculum. She stated that studies were "primarily descriptive, relates mostly to technology educators' ideas and practices, is concerned with secondary school technology education, and is the result of a small number of researchers working at a handful of institutions" (p. 19). Studies of teachers' attitudes about the curriculum indicated no significant shift from traditional conceptions of industrial arts to more contemporary ideas of technology education. Though some teachers accepted some terminology change, they had not moved very far away from the traditional goals in the field. Zuga also indicated that only a few studies used qualitative methods, and those that did were conducted outside the United States. Other technology education researchers (see Hoepfl, 1997; Johnson, 1995) suggested that technology educators should engage in research that probes for deeper understanding. They also advised that

qualitative methodologies provide powerful tools for enhancing understanding of teaching and learning in technology education.

Petrina (1998), in a meta-study of articles published in the *Journal of Technology Education* (JTE), asserted that technology education researchers shy away from situating the field against the backdrop of the politics of education, and in so doing have missed opportunities to bring a critical theory lens to the issues that surround the field. Indeed, Petrina was not alone in his perspectives, as others thought (see Herschbach, 1997; Newman, 1994) that technology education as a discipline was self-absorbed, focusing on the discipline of technology rather than on the mainstream educational issues that were dividing the public, and thus was failing to gain greater recognition by Americans. They suggested that technology education needed to show its capacity to address the prevailing issues if it wanted to gain public support. Petrina identified several framing questions to shape the kind of research that needed to be conducted in technology education. They were:

- How do students, teachers, teacher educators, and the general public come to practice, use, and understand education and technology?
- Toward what end are we committing technology education?
- What is and ought to be the nature of knowledge in technology education?
- How should this knowledge be organized, what ought to be selected for teaching, how should it be taught, and for what end?
- How was technology education practiced in the past?
- How is or was technology education practiced in subcultures and in other cultures?
- Who participates in technology education and why or why not?

According to Sanders (2001), at the beginning of the 21st century, technology education programmes outnumbered industrial arts programmes six to one, with industrial technology programmes claiming most of the middle ground. Practitioners reported teaching problem solving as the most important purpose of the field, supplanting the emphasis on skills development. Three programmes in four were using either the modular technology education or technological problem-solving approach to instruction. Significant demographic shifts transformed the faculty and students of technology education, and the field was reaching a greater range and percentage of students than ever. For decades, the literature has encouraged new content for technology education, and the findings of Sander's (2001) study suggested that communication, manufacturing, construction, and transportation

technologies are increasingly represented in the curriculum, with biotechnology represented at a lesser degree despite 10 years of encouragement from the profession. He also indicated that there seems to be continued ambivalence regarding the relationship of technology education to vocational and general education. Despite efforts throughout the 20th century to distance technology education from vocational education, there is considerable evidence of the sort of "border crossings" alluded to by Lewis (1996).

Standards for Technological Literacy

The publication *of Standards for Technological Literacy: Content for the Study of Technology* (STL) in 2000 was a milestone in the professional repertoire of the ITEA, because it marked the first time a national standard was created that provided a framework for technological literacy for K-12. The project extended beyond the mere provision of content standards to later include accompanying standards for programmes, student assessment, and professional development for technology education teachers produced in 2003.

The term *technological literacy* was certainly not a novel phrase among technology educators (Snyder, 2004). The need for technology education for all had been raised as far back as 1948 in the journal *The Industrial Arts Teacher,* when Mr. Walter R. William, the then President of the American Industrial Arts Association (which later became the ITEA) remarked that:

> the pressure of a complex technological society, the narrow view of the manual arts concept is fast giving way to a more comprehensive and flexible interpretation of industrial arts or technology. That a crucial need exists for *technological literacy* is apparent. (p. 1)

Over time, the term became a frequent part of the vocabulary of technology educators and the goal of their professional organization (Snyder, 2004). The term *technological literacy* refers to one's ability to use, manage, evaluate, and understand technology (ITEA, 2000).

The STL consists of 20 technology content standards divided by grade levels K-2, 3-5, 6-8, and 9-12. The standards set forth goals to be met in the five major categories of technology: (a) the nature of technology, (b) technology and society, (c) design, (d) abilities for a technological world, and (e) the design world. Each standard consists of benchmarks, which are statements that enable students to meet a given standard. Benchmarks reflect a:

progression from basic ideas at the early elementary school level to the more complex and comprehensive ideas at the high school level, and continuity in core concepts across grade levels to ensure the learning of important topics related to a standard. (Dugger, 2002, p. 97)

The STL is not a federal mandate—the standards are voluntary and merely serve as guidelines that states can use to develop K-12 curricula that have the necessary rigour and which address the knowledge, skills, and habits of minds that are essential for the development of technological literacy (Dugger, 1999).

Some will argue that STL, in its comprehensive enunciation of what is required to develop a technologically literate society, addresses some of the issues and questions posed about curricular direction throughout the 1990s. Others may disagree. Nonetheless, the standards produced by the ITEA represented great strides made by the organization to sensitize and institutionalize technology literacy education. The need, however, for more research that focuses on critical elements in technology education was still urgent. In an article published in the *Journal of Technology Education* a year before the STL was published, Lewis (1999b), reiterating some of the concerns raised in previous years by some technology education researchers (see Foster, 1992, 1995; Petrina, 1998; Wicklien, 1993; Zuga, 1994), espoused what he believed were major areas of research needed in technology education. The rationale behind his recommendations was that schools constituted the primary site of inquiry in technology education, so that the ethos of classrooms and laboratories where the subject is taught must be the prime area of focus. Areas of research that needed to be addressed in detail, as seen by Lewis (1999b), were technological literacy and conceptions or misconceptions held by students, perceptions about technology, technology and creativity, gender and technology education, curriculum change and integration, and teacher development.

While the STL was directed at K-12 students, there were other efforts outside of the ITEA that were directed at producing standards that address technological literacy. These efforts targeted undergraduate education, and the technical world provided useful information for the organization of topics. In 1993, the American Association for the Advancement of Science (AAAS) published *Project 2061: Benchmarks for Science Literacy*. The AAAS devoted one chapter to the "Designed World." The focus was the products of engineering and their impact on daily life. Topics covered were agriculture, materials and manufacturing, energy sources and use, communications, information processing, and

health technologies. The benchmark recommendations emphasized that technology is a human activity that shapes our environment and lives (AAAS, 1993). In addition, in 1996 the National Academies produced the *National Science Education Standards*. This document contained a section devoted to technology. A notable inclusion was the importance of the design process as a defining aspect of technological endeavors (NRC, 1996).

Technically Speaking

The report *Technically Speaking* was produced after a two-year study, commencing in 2000, by the Committee on Technological Literacy. The committee consisted of a group of experts on diverse subjects, under the auspices of the NAE and the NRC Center for Education. The committee's charge was to begin to develop among relevant communities a common understanding of what technological literacy is, how important it is to the nation, and how it can be achieved. The charge reflected the interests and goals of the two project sponsors—the NSF and Battelle Memorial Institute—as well as the priorities of the National Academies (Pearson et al., 2002). The report was released publicly at a symposium held at the National Academies in January 2002. The report pointed out that technological literacy encompasses three interdependent dimensions—knowledge, ways of thinking and acting, and capabilities—and its goal is to provide people with the tools to participate intelligently and thoughtfully in the world around them (see Figure 1).

The committee reviewed past and present initiatives and made recommendations that addressed four areas: (1) formal and informal education, (2) research, (3) decision making, and (4) teaching excellence and educational innovation. The specific recommendations were:

1. Federal and state agencies that help set education policy should encourage the integration of technology content into K-12 standards, curricula, instructional materials, and student assessments in non-technology subject areas.

2. The states should better align their K-12 standards, curriculum frameworks, and student assessment in the sciences, mathematics, history, social studies, civics, the arts, and language arts with national educational standards that stress the connections between these subjects and technology. National Science Foundation (NSF) and Department of Education (DoEd) funded instructional materials and informal-education initiatives should also stress these connections.

Characteristics of a Technologically Literate Citizen

Knowledge

- Recognizes the pervasiveness of technology in everyday life.
- Understands basic engineering concepts and terms, such as systems, constraints, and trade-offs.
- Is familiar with the nature and limitations of the engineering design process.
- Knows some of the ways technology shapes human history and people shape technology.
- Knows that all technologies entail risk, some that can be anticipated and some that cannot.
- Appreciates that the development and use of technology involve trade-offs and a balance of costs and benefits.
- Understands that technology reflects the values and culture of society.

Ways of thinking

- Asks pertinent questions, of self and others, regarding the benefits and risks of technologies.
- Seeks information about new technologies.
- Participates, when appropriate, in decisions about the development and use of technology.

Capabilities

- Has a range of hands-on skills, such as using a computer for word processing and surfing the Internet and operating a variety of home and office appliances.
- Can identify and fix simple mechanical or technological problems at home or work.
- Can apply basic mathematical concepts related to probability, scale, and estimation to make informed judgments about technological risks and benefits.

Figure 1. Characteristics of a Technologically Literate Citizen (Adopted from *Technically Speaking*, National Academies Press, 2002).

3. NSF, DoEd, state boards of education, and others involved in K-12 science education should introduce, where appropriate, the word "technology" into the titles and contents of science standards, curricula, and instructional materials.

4. NSF, DoEd, and teacher education accrediting bodies should provide incentives for institutions of higher education to transform the preparation of all teachers to better equip them to teach about technology throughout the curriculum.

5. The National Science Foundation should support the development of one or more assessment tools for monitoring the state of technological literacy among students and the public in the United States.

6. The National Science Foundation and the Department of Education should fund research on how people learn about technology, and the results should be applied in formal and informal education settings.

7. Industry, federal agencies responsible for carrying out infrastructure projects, and science and technology museums should provide more opportunities for the nontechnical public to become involved in discussions about technological developments.

8. Federal and state government agencies with a role in guiding or supporting the nation's scientific and technological enterprise, and private foundations concerned about good governance, should support executive education programs intended to increase the technological literacy of government and industry leaders.

9. U.S. engineering societies should underwrite the costs of establishing government- and media-fellow programs with the goal of creating a cadre of policy experts and journalists with a background in engineering.

10. The National Science Foundation in collaboration with industry partners should provide funding for awards for innovative effective approaches to improving the technological literacy of students or the public at large.

11. The White House should add a Presidential Award for Excellence in Technology Teaching to those that it currently offers for mathematics and science teaching. (Pearson et al., 2002, pp. 8–10)

The recommendations reflected the eclectic influence of technology in the lives of all American citizens and the structured actions that were necessary to embrace technological literacy for all. At the same time, the important role that design should play in advancing technological literacy was becoming obvious, as reflected by the various standards on STEM. Research and discussion about the ontology of design and the format it should take in technology education occupied a significant number of research articles post-STL.

Design in Technology Education

Unlike any other curricular endeavour that preceded it, STL points to the importance of a holistic grasp of design when developing technological literacy. It states that:

> to become literate in the design process requires acquiring the cognitive and procedural knowledge needed to create a design, in addition to familiarity with the processes by which a design will

be carried out to make a product or system. (Warner & Morford, 2004, p. 90).

Four of the 20 standards in STL relate to design, and the design theme is woven throughout many benchmarks (Warner & Morford, 2004). Lewis (2005, p. 35) argued that design is the "single most important content category set forth in the standards, because it is a concept that situates the subject more completely within the domain of engineering." The imprimatur of the standards document, in its foreword by the then President of the National Academy of Engineering (NAE), Williams Wulf, reflects confidence at the highest level of the engineering community in the standard's framework to appropriately address important engineering design principles at the pre-college level. Tables 1 and 2 illustrate the design standards and some benchmarks.

Table 1. Design Standards From the Standards for Technological Literacy

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Design (Chapter 5)

Standard 8. Students will develop an understanding of the attributes of design.

Standard 9. Students will develop an understanding of engineering design.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World (Chapter 6)

Standard 11. Students will develop the abilities to apply the design process.

Table 2. Sample of Design Standards and Benchmarks

Standard 11. Students will develop abilities to apply the design process.
As part of learning how to apply design processes, students in grades 6-8 should be able to:

H. Apply a design process to solve problems in and beyond the laboratory-classroom. Perform research, then analyze and synthesize the resulting information gathered through the design process. Identify and select a need, want, or problem to solve, which could result in a solution that could lead to an invention (an original solution) or an innovation (a modification of an existing solution). Identify goals of the problem to be solved. These goals specify what the desired result should be.

I. Specify criteria and constraints for the design. Examples of criteria include function, size, and materials, while examples of constraints are costs, time, and user requirements. Explore various processes and resources and select and use the most appropriate ones. These processes and resources should be based on the criteria and constraints that were previously identified and specified.

J. Make two-dimensional and three dimensional representations of the designed solution. Two-dimensional examples include sketches, drawings, and computer-assisted designs (CAD). A model can take many forms, including graphic, mathematical, and physical.

K. Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. Testing and evaluation determine if the proposed solution is appropriate for the problem. Based on the results of the tests and evaluation, students should improve the design solution. Problem-solving strategies involve applying prior knowledge, asking questions, and trying ideas.

L. Make a product or system and document the solution. Group process skills should be used, such as working with others in a cooperative team approach and engaging in appropriate quality and safety practices. Students should be encouraged to use design portfolios, journals, drawings, sketches, or schematics to document their ideas, processes, and results. There are many additional ways to communicate the results of the design process to others, such as a World Wide Web page or a model of a product or system.

The inclusion of design, however, raises questions about the difference between technological design and engineering design. Concerns were also raised about what engineering design concepts and processes should be taught in K-12, the preparedness of technology education teachers to teach engineering design, the cognitive processes of students when they solve a design problem, and the appropriate instructional strategies to teach engineering design in response to the new standards (see Lewis, 2005). These all were questions about content and process; however, the focus of most discourses generated in part by these questions primarily centred on the nature of design in technology education.

Research focusing on design post-STL included that by Custer, Valesey, and Burke (2001), which validated an instrument for assessing student learning in design and problem solving. Warner and Morford (2004) provided evidence that design in the curriculum content experienced by pre-service technology teachers during their undergraduate studies was deeply rooted in the technical aspects of the

design process, without much emphasis on design concepts. Lewis (2005) addressed the adjustments that need to be made within technology education for the field to come to terms with engineering as content. He opined that these adjustments must not be limited to curriculum and instructional strategies, but must necessarily impact inquiry and teacher preparation methodologies.

Other types of curriculum and pedagogical conceptualizations also influenced the discourse about the structure of design in technology education. These curriculum concepts included an integrative approach to design that incorporates mathematics and applied science, in keeping with the cross-cutting nature of engineering (Roman, 2001); a proposal that mathematical theories be applied to design in technology education classrooms to encourage students to use mathematics to predict the outcomes of their designs (Cotton, 2002); and suggestions that students spend more time engaged in research and redesign activities (Neumann, 2003).

Against the backdrop of an economy that demanded more students in STEM disciplines who are critical thinkers and innovative problem solvers, more educators were searching for engaging curricula that integrate STEM to achieve these educational outcomes. The STL was gradually being accepted by an increasing number of states to guide the development of technology curricula for K-12. More STEM educators were also recognizing the potential of design, particularly engineering and technological design, to provide engaging scenarios that allow students to apply knowledge from science, mathematics, technology, and engineering to solve authentic problems. The establishment of a Center for Learning and Teaching (CLT) by NSF would prove to be instrumental in promoting an understanding of how engineering design can be infused in K-12 schools.

The National Center for Engineering and Technology Education (NCETE)

The NCETE was established on September 15, 2004, and was funded by the NSF as one of the 17 CLTs in the country. The Center comprised a strong team of partners from nine universities and four professional organizations. The university partners were Brigham Young University; California State University, Los Angeles; Illinois State University; North Carolina A&T State University; University of Georgia; University of Illinois at Urbana-Champaign; University of Minnesota; University of Wisconsin-Stout; and Utah State University. The professional society partners were the International Technology and Engineering Educators

Association (ITEEA); the American Society for Engineering Education (ASEE); the Council on Technology Teacher Education (CTTE, now Council on Technology and Engineering Teacher Education (CTETE)); and the Center for the Advancement of Scholarship on Engineering Education (CASEE).

According to Hailey, Erekson, Becker, and Thomas (2005, p. 23), the ultimate goal of NCETE is to infuse engineering design, problem solving, and analytical skills in K-12 schools through technology education, and to increase the quality, quantity, and diversity of engineering and technology educators. Engineering faculty and technology educators collaborated in a systematic way to accomplish the following:

1. Build a community of researchers and leaders to conduct research in emerging engineering and technology education areas.

2. Create a body of research that improves our understanding of learning and teaching engineering and technology subjects.

3. Prepare technology education teachers at the BS and MS level who can infuse engineering design into the curriculum (current and future teachers).

4. Increase the number and diversity of students selecting engineering, science, mathematics, and technology career pathways.

The formation of NCETE represented in part a direct response to the ongoing discourse about the format that engineering design should have at the high school level. One of the goals of NCETE was to work with engineering and technology educators to prepare them to introduce engineering design concepts in Grades 9-12. Comparing the mission of the Center with the requirement of the STL, Hailey et al. (2005) further enunciated that the design process described in *Standard 8* is very similar to the introductory engineering design process described in freshman engineering design textbooks. The exception exists in the teaching of analysis in freshman engineering programmes as the decision-making tool for evaluating a set of design alternatives, where "analysis" means the analytical solution of a problem using mathematics and principles of science (p. 25).

Introducing students in Grades 9-12 to the role of engineering analysis in the design process positions technology education more in the realm of engineering, and also increases its value as a knowledge domain that integrates mathematics and science—thus strengthening the STEM connection. NCETE's website displays over 150 studies and numerous outreach activities accomplished by the faculty and graduates of the

Center and its nine partnering universities from 2004–2012 (see http://ncete.org/flash/publications.php), which directly relate to its mandate to infuse engineering design problem solving and analytical skills in schools. Areas addressed by these studies and outreach activities include:

- Feature of engineering design in technology education
- Professional development of technology teachers to teach engineering design
- Teaching engineering concepts
- Creativity
- Cognitive processes in design problem solving
- Integrating mathematics and science in engineering and technology education
- Assessment in design
- Engineering challenges

Table 3 highlights dissertations published by doctoral fellows of NCETE.

Table 3. List of NCETE Fellow Dissertations

Austin, C. (2009). *Factors influencing African-American high school students in career decision self-efficacy and engineering-related goal intentions* (Unpublished doctoral dissertation). University of Minnesota, Minneapolis.

Avery, Z. K. (2009) *Effects of professional development on infusing engineering design into high school science, technology, engineering and math (STEM) curricula* (Unpublished doctoral dissertation). Utah State University, Logan.

Daugherty, J. L. (2008). *Engineering-oriented professional development for secondary level teachers: A multiple case study analysis* (Unpublished doctoral dissertation). University of Illinois at Urbana-Champaign.

Denson, C. D. (2008). *Impact of mentorship programs to influence African-American male high school students' perception of engineering* (Unpublished doctoral dissertation). University of Georgia, Athens.

Dixon, R. (2010). *Experts and novices: Difference in their use of mental representation and metacognition in engineering design* (Unpublished doctoral dissertation). University of Illinois at Urbana-Champaign.

Franske, B. (2009). *Engineering problem finding in high school students* (Unpublished doctoral dissertation). University of Minnesota, Minneapolis.

Kelley, T. (2008). *Examination of engineering design in curriculum content and assessment practices of secondary technology education* (Unpublished doctoral dissertation). University of Georgia, Athens.

Lammi, M. (2010). *Characterizing high school students systems thinking in engineering design through the function-behavior-structure (FBS) framework.* (Unpublished doctoral dissertation). Utah State University, Logan.

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Mentzer, N. (2008). *Academic performance as a predictor of student growth in achievement and mental motivation during an engineering design challenge in engineering and technology education* (Unpublished doctoral dissertation). Utah State University, Logan.

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Source: http://ncete.org/flash/publications_dis.php

NCETE's final report to NSF in 2012 identified the lack of a clear disciplinary standards-based home for engineering design experiences as the main challenge that faces professional development of technology education teachers. The report also mentioned that the infusion of engineering design into high school courses is scattered across mathematics, technology, and science, and there is a considerable quantity of curriculum material available to guide teachers and professional developers. The report further added that presenting students with opportunities to engage in engineering design requires a paradigm shift from the traditional classroom environment to one where teachers establish an environment that encourages students to take ownership of the engineering design challenge, identify needs or wants that are personally important or relevant to them, frame the design problem with applicable criteria and constraints, generate alternative solutions, evaluate competing ideas, and carry out the testing of prototypes.

Concurrent developments in engineering education organizations, such as moves to embrace engineering content at the K-12 level, coupled with the implementation of structures to develop and support teachers in the delivery of this content, also impacted technology education. For example, in 2003 the American Society for Engineering Education (ASEE) added the K-12 Division and initiated K-12 workshops at the 2004 ASEE conference. In 2006, the National Academy of Engineering (NAE) established the Committee on K-12 Engineering Education to explore K-12 engineering curricula and instructional practices (NCETE, 2012).

Indubitably influenced by the national context and ongoing developments in engineering education associations and professional

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bodies, the ITEA changed its name to the International Technology and Engineering Educators Association (ITEEA). In a release to the technology education community in March 2010, the ITEEA stated in part:

> This change causes the association to immediately address curriculum and professional development that includes both technology and engineering education at the K-12 level. The association's membership has been comprised of teachers who have been working in both areas and with many of its affiliates already having "engineering" in their association's title.
>
> The term engineering is not new to the technology teaching profession; it has been used for over a century in various course titles, discussions, and curriculum efforts. The engineering community played a key role in the creation of this subject area as it has gone through various name changes as industry and technology have changed.
>
> The name change properly positions the association to deal with the 'T' & 'E' of a strong STEM education. ...ITEEA's continuing initiatives with the Engineering by Design™ curriculum work further add to the promotion of technology and engineering at the K-12 school level…

Since the name change to ITEEA, other events at the national level pointed to deliberate efforts to include engineering content in K-12 schools. In 2011, 12 states included engineering in science standards and one in mathematics standards. Nineteen states included engineering related to standards promoted by ITEEA or "Project Lead the Way" (NCETE, 2012). The 2012 *Framework for K-12 Science Education* stated that engineering and technology would be part of the new science standards. The National Assessment of Education Progress (NAEP) includes technology and engineering literacy in its 2014 assessment as distinct literacies.

Pre-Engineering and STEM

A description of the trend in technology education would not be complete without addressing other curricular trends that have influenced technology education. In 2004, Lewis argued that the phenomenon of pre-engineering was the most recent claimant to the technology education tradition. He reasoned that:

> while it constitutes an epistemological advance, pre-engineering also represents a decided sociological calculation, that hopes to make the subject more palatable to the tastes of the academics who run schools, and the middle and upper classes, whose children turn away from the base subject after the compulsory stages in the middle grades, as they fix their attention on the college track, and upon professional careers. (p. 22)

Lewis spoke about four conceptions of pre-engineering, identifying them as:

- Career academy conception – Academies are intended to bridge the gap between academic and vocational education. Programs prepare students both for two and four-year colleges by combining a college preparatory curriculum with a career theme and courses that meet high school graduation and college preparatory requirements.

- Magnet school conception – Magnet schools are district-wide specialty schools, which emerged as a means of desegregating school systems. One curricular approach is to focus these schools around particular themes. Parents send their kids to these racially mixed schools with the prospect of exposing them to innovative curricula.

- Regular conception – This refers to the curriculum initiatives that infuse engineering design in the context of manufacturing, construction, transportation, communication, power and energy, and management – the core areas of technology education.

- Movement conception – A version of pre-engineering that uses a course sequence option that sets the stage for possible enrollment in engineering programs in two and four-year colleges.

These conceptions tend to adopt a curricular structure that uses a particular discipline, such as science or mathematics, as a platform for the integration of engineering and technology; or technology and engineering to integrate mathematics and science concepts. Curricula associated with these pre-engineering conceptions have emerged to represent exemplar attempts to integrate STEM. Brophy, Klein, Portsmore, and Rogers (2008) described some of the more popular curricula in use at elementary and high schools.

Project Lead the Way

Some view the "Project Lead the Way" (PLTW) curriculum as exemplary in providing high schools with pre-engineering activities and linkages to college-level engineering and engineering technology

programmes (Bottoms & Anthony, 2005; McVearry, 2003). PLTW is a non-profit organization that works with public schools, the private sector, and higher education to increase the quantity and quality of engineers and engineering technologists, by giving students the opportunity to design solutions to various problems. They offer a multi-year problem-based/project-based curriculum that has been adopted by over 1,400 schools (7% of all U.S. high schools) in all 50 states and the District of Columbia (Tran & Nathan, 2010). Curricula are provided for both middle and high schools. The middle school curriculum introduces students in Grade 6 through 8 to the broad field of technology. The standard-based pre-engineering curriculum, *Pathway to Engineering*™, is designed for high schools. It challenges students to solve real-world engineering problems by applying their knowledge and skills in mathematics, science and technology.

In the state of Massachusetts where this curriculum has been adopted, engineers advocate for the importance of technology education, resulting in it being viewed as high-status and the state conceiving the subject as a derivative of engineering and so framing it in tight connection with science. According to Lewis (2005):

> Throughout the grades, the curriculum guide takes an engineering slant. In grades 3-5, students learn about tools and materials, and are expected to display "engineering design skill" by finding and proposing solutions to problems, working with a variety of tools and materials. In grades 6-8, students are expected to "pursue engineering questions and technological solutions that emphasize research and problem solving." In the grades 9 and 10 they take a full year technology/engineering course covering engineering design; construction technologies; power and energy technologies in fluid, thermal and electrical systems; communication technologies; and manufacturing technologies. In grades 11 and 12 students can take advanced courses such as automation and robotics, multimedia, and biotechnology. At this level there is a strong engineering careers focus, with course sequences available for students intending to pursue engineering programs at the college level. (p. 32)

Teachers in Indiana also embraced the PLTW curriculum, seeing it as a valuable component of technology education and beneficial for technological literacy (Rogers & Rogers, 2005). The state has the highest per capita inclusion of PLTW in the nation. The curriculum is included in the State's technology education curriculum, and PLTW teachers are

required to hold a technology education teaching licensure (Rogers, 2006). In a study conducted among technology education teachers, Rogers (2006) concluded that Indiana's PLTW teachers perceive all the courses in the PLTW curriculum as being effective in developing pre-engineering competencies in their high school students. Figure 2 illustrates some of the curricula that are used at the middle and high school levels to develop technological literacy through a pre-engineering focus.

Pre-Engineering Program	Description
Engineering by Design (EbD)	The International Technology and Engineering Educators Association's STEM Center for Teaching and Learning™ has developed the only standards-based national model for Grades K-12 that delivers technological literacy. The model Engineering by Design™ is built on Standards for Technological Literacy (ITEEA); Principles and Standards for School Mathematics (NCTM); and Project 2061, Benchmarks for Science Literacy (AAAS). The EbD is used in many school districts in the USA to teach to the STL.
Engineering is Elementary (EiE)	This is one of the largest elementary engineering curriculum development projects. It focuses on integrating engineering with reading literacy and existing science topics in the elementary grades. It was originally developed at the Boston Museum of Science to meet new engineering standards like those defined by Massachusetts. EiE is aligned with national and many state standards and integrated with science, language arts, mathematics, and social studies. Some pre-service teacher education programs use these materials in their courses. EiE also provides in-service professional development for educators who want to implement the curriculum.
LEGOengineering	This is the most prominent project of Tufts Center for Engineering Education Outreach. The center initially selected the LEGO material to implement the majority of its engineering efforts at the K-12 levels as well as at the college level, because of their ease of use as well as their power to enable students in hands-on engineering design. The

	LEGO toolkit gives students the opportunity to design solutions to various problems, while still allowing them to make changes with their design. They can create working products of significant complexity while still remaining open-ended. The LEGOengineering-inspired books and activities help to give educators at the elementary, middle, and high school /college level basic activities to bring engineering into the classroom and teaching engineering content.
The Infinity Project	The Infinity Project was developed in 1999 by the Institute for Engineering Education at the Southern Methodist University, Texas Instruments working in partnership with the U.S Department of Education, the National Science Foundation, and others. It brings the theme of technology literacy and engineering into middle and high schools through a curriculum that focuses on advanced topics in digital signal processors (DSPs), including the internet, cell phones, digital video and movie special effects, and electronic music.
Vanderbilt Instruction in Biomedical Engineering for Secondary Science (VIBES)	VIBES started in 1999. The project was funded through the National Science Foundation's Vanderbilt – Northwestern-Texas-Harvard/MIT Engineering Research Center (VaNTH ERC). Vibes consists of learning modules to teach a high school level engineering course, a physics course, or portions of an anatomy or physiology course. Teachers participating in VIBES must be teaching a relevant course and have approval from their home school to participate in VIBES workshop.

Figure 2. Examples of pre-engineering curricula.

The strong design focus of PLTW and other curricula highlighted in Figure 2 reflect the emphasis on creative problem solving. *Standards for Technological Literacy* emphasize the use of problem-solving strategies in teaching to enhance creativity. Design is ideal for creative thinking because of its open-endedness and the fact that there is more than one possible answer and more than one method of arriving at a solution (McCormick & Davidson, 1996). Design also requires students to use analogical reasoning and divergent thinking processes—cognitive processes that enhance creative abilities (Lewis 2005).

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A Picture of What's Happening in Schools

Articles appearing in the *Technology and Engineering Teacher* Journal (formerly *The Technology Teacher*) help to paint a picture of what technology education teachers have been accomplishing in the classroom. The four-year period from 2008 to 2012 saw the emphasis on design and integrative STEM. For example, Frazier and Sterling (2008) related how they used "motor mania" as a topic to let students experience at first hand the relationship between science and technology applications, such as getting a car to function well. This problem-based learning activity takes middle school students through the various stages of the design process to solve a technological problem. The learning engagements provide a means for students to function as scientists and engineers as they work towards solving a specific real-world problem situation with technological design. Verma, Dickerson, and McKinney (2011) demonstrated how an innovative project-based curriculum, "The Marine Tech Project," helped students to learn about ship design, construction, ship operations, and ship stability concepts.

Sanders (2009, p. 23), addressing the importance of integrative STEM in technology education classrooms, said that it "provides a context and framework for organizing abstract understandings of science and mathematics and encourage students to actively construct the contextualized knowledge of science and mathematics, thereby promoting recall and learning transfer." There are also accounts of teachers implementing integrative STEM in their own courses. Silk, Hagashi, Shoop, and Schunn (2010) spoke about designing and redesigning robotics units to teach mathematics. Bellamy and Mativo (2010) discussed using real-life situations in the technology education classroom to teach mathematics, and Gathing (2011) illustrated how mathematics can be integrated into technology classes by using bridge design in the teaching of trigonometry.

Other articles in the *Technology and Engineering Teacher* journal also illustrate how integrative STEM is being introduced in technology education through teachers working across disciplines. For example, Pendergraft, Daugherty, and Rossetti (2009) spoke of how the English language learner programme at the Engineering Academy at Springdale High School, Arkansas used engineering design activities to introduce students to the open-ended and multidisciplinary nature of engineering. The challenging design problems provided students with opportunities to apply the science, math, and technology concepts they had been studying in their associated classes. Piotrowski and Kressly (2009) spoke of the benefits of cooperative classroom robotics, which bring teachers from

mathematics, science, and even English, to the technology education lab. Lawrence and Mancuso (2012) explained how girls' awareness and interest in engineering are promoted in the "Girls Excited about Engineering, Mathematics and Computer Science" (GE2McS) NSF initiative in schools. Brown, Brown, and Merrill (2012) explored possible ways in which mathematics, science, and technology education teachers could collaborate in teaching biotechnology, medical technology, and engineering. The journal contains numerous examples of exemplary teaching and curriculum that address robotics, CNC machining, communications technology, nanotechnology, medical technology, alternative energy, green technologies, construction technology, design challenges, and animation/ simulation in design.

Despite the role that technology education teachers at the middle and high school level are playing in integrating STEM, particularly through technological and engineering design, in a survey study conducted among supervisors in school districts across 50 states, Moye, Dugger, and Starkweather (2012) found that technology and engineering teachers are not being counted in major state STEM initiatives. Technology teachers are either non-existent or loosely counted in many databases. They go on to add that states often see "STEM" as what mathematics and science teachers do. They recommend that emphasis must be placed on ensuring that technology education teachers are also included in this group.

The progression of technology education in the USA for the past 20 years reflects the gradual acceptance for technological literacy to be delivered as general education. To that end, national standards have been produced for all grade levels. While technology education is still not a compulsory curriculum, its role in teaching integrative STEM is recognized by many in mathematics, science, and engineering education. The decision to include standards that address science and engineering practices; engineering design; and science, technology, society, and the environment, in the new *Next Generation Science Standards* (Achieve, Inc., 2013) for K-12 schools is indicative of how closer to this realization the nation has come.

Lessons for the Caribbean

The Caribbean can learn from these efforts to produce technology standards to ensure that its citizenry is also characterized by technological literacy. Indeed, this cannot be overemphasized in a world where technology is becoming pervasive at every level of society. The Caribbean as a region, however, will lag behind other nations in

producing a technologically literate society if regional initiatives are not taken to develop frameworks through which this can be achieved. I will now—without being prescriptive—articulate some broad approaches that are needed in the Caribbean to address technological literacy from the primary to the secondary level of the educational system.

Technological Standards for the Region

For the Caribbean region to remain competitive in the present, and also in a future global economy, the region must move beyond viewing general education as being defined only by the language arts, mathematics, and the sciences. Literacy must also encompass understanding the nature of technology, and every student from the primary to the secondary level must be exposed to systematic, age-appropriate curricula that allow this to be achieved. To attain this egalitarian goal, there must be standards that govern the content of technology that is taught at the primary and secondary levels throughout the region. The establishment of such standards will provide guidelines for technology teaching practice and an evaluative framework, which will ensure that the region is producing secondary school students with the technological foundation to be successful in postsecondary education (academic or vocational), and who are also ready for entry-level positions in advanced technology industry. In the long term, the region's populace will be characterized by high levels of technological competency. Visions of a common economic region only accentuate the importance of such standards; without which parity in technological outcomes among the islands will be difficult to guarantee.

Technology literacy standards must be driven by a socio-economic analysis of the region's technological infrastructure, which should produce a classification of core technological areas for learning from the primary to the secondary level. For example, the STL classified five core technological areas in which students in the USA should be literate—energy, transportation, manufacturing, communication, and construction. Similarly, such a classification is required for the Caribbean region. Indeed, Girvan (2007) might have inadvertently identified some aspects of this classification when he identified energy, manufacturing, and agriculture as some of the main economic drivers of Caribbean regional development. Regional efforts, however, must be invested in research to define these core technological areas and the relevant standards that govern their learning. This must be followed by policies instituted by the regional ministries of education to develop curricula, student assessments, and teacher development programmes to

meet the requirements of these standards from primary to secondary levels (Dugger, 1999).

Standards have the capacity to influence change in the fundamental delivery mechanism of the educational system. Standards for technological literacy—as general education—that have the endorsement of the education ministries in the Caribbean, can influence how education is delivered at the primary and secondary levels. The following are three ways in which this might be possible.

First, the existence of a standard document for technological literacy for primary education will influence the development of curricular materials, methods of assessment, teacher education and development programmes, as well as infrastructural changes to ensure that the outcomes relating to these standards are achieved. One way in which colleges can address technological literacy requirements at the primary level is to have integrative STEM teacher education certification programmes. The basic nature of technology required at the primary level should not make this difficult to achieve at teacher training colleges. The indigenous materials available in the Caribbean, as well as the plethora of computer-assisted learning educational software that can allow students to explore math, science, and technology, are resources that can be used to enrich the learning of STEM at the primary level. Off-the-shelf, low cost, and low maintenance equipment are also available, which provide educational engagements requiring scientific inquiry, mathematics, and technological problem solving. Dugger (1999) offers some useful insights into technology learning at the primary level. He indicated that technology at the elementary level involves much more than products and computers. Technology has its own intellectual domain, which every student should learn along with science, mathematics, language arts, and social studies. Lewis (1999a) also added that technology education in a poor country cannot be premised on the same content as in affluent countries, but technology in schools must be concerned with exciting and delighting children. The key is to foster interest in careers with a technological focus by allowing students to have opportunities to engage in rich technological experiences from an early age (ACARA, 2012).

Second, the secondary entrance assessment (known as GSAT in Jamaica and BSSE in Barbados) that is used each year in some islands to place students in secondary schools should also assess for technological outcomes. This will ensure that students enter secondary education programmes with the required technological foundation.

Third, technology literacy standards for secondary level must also include a progression in the development of engineering outcomes.

Engineering principles, engineering design, material science, and other relevant engineering focus must also be addressed in such a document. Having a consistent framework to guide secondary teachers throughout the Caribbean will help to assure the general public that students possess the technological foundation to advance into various STEM fields at the college level. A solid foundation will also be provided for students who choose technical and vocational areas. The Caribbean Secondary Education Certificate (CSEC) and the Caribbean Advanced Proficiency Examination (CAPE) can use these standards as a framework to assess for technological outcomes.

A Note on TVET

While standards that govern technological literacy are very important for primary and secondary level education, this does not somehow negate the need for occupational standards to ensure that Caribbean students are acquiring specific job competencies at the appropriate proficiency while they are still in secondary school. Both standards used in synergy will produce a technologically literate and technically competent populace; technological standards will ensure that general proficiency in technology is achieved, while occupational standards will ensure that students achieve specific job competencies for targeted occupational areas. The latter standards are derived from job or occupational analysis normally carried out by the Councils of Technical and Vocational Training in the respective islands that have such an institution. In fact, for some years now, Caribbean Vocational Qualifications (CVQs) that serve to standardize skills expectations across the region have been in existence (Lewis, 2007).

Much can be learned from Newly Industrialized Countries such as China and Korea, which share a new vision of the role of technical and vocational education and training (TVET), seeing it as equally important to equip students with the life skills of the 21st century (UNESCO, 2005). In these countries, increasing numbers of secondary school students are enrolled in TVET programmes that have a strong academic focus. In some schools, academic and vocational students share 75% of a common curriculum (Lewis, 2007). Regardless of the configuration used, the salient point is that TVET must be an integral part of the regional strategy to develop a technologically capable, equitable, and sustainable region.

The institutional infrastructure of the islands in the Caribbean necessitates that a diverse approach to delivering TVET be used. For example, secondary schools can partner with TVET agencies,

community and technical colleges, and private enterprises to deliver the first level (Level 1) of TVET qualifications. Level 1 programmes can be delivered at secondary school campuses as joint endeavours between secondary schools and national training agencies. Facilities at community colleges or training centres can also be used if secondary schools do not have the infrastructure. With this approach, students can concurrently complete vocational curricula, while completing Grades 9-11of the technology standards, to be ready for entry into the workforce. An obvious advantage of using this configuration is that students can meet standards for entry into particular technical occupations before completing secondary school. This would help to minimize expenses that companies accrue from training workers in entry-level technical skills, and lead to the diversion of these resources to advanced technological training. Such a partnership between schools and training agencies can result in access to facilities, equipment, and other resources that normally would be difficult for the schools because of budgetary constraints. Moving Level 1 TVET programmes into secondary schools will strengthen the collaboration among schools, industry, and TVET agencies. Industries and TVET agencies will have more influence in school curricula and administration. Industry, in particular, could provide opportunities for apprenticeship placements, scholarships, and their personnel can serve on school boards, and advisory committees.

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