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Technology education in Hong Kong: trends, challenges and potentials

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4201

TECHNOLOGY EDUCATION IN HONG KONG – TRENDS, CHALLENGES AND POTENTIALS

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Abstract

While education promotes technological changes, it also responds to technological changes. Technology education, with the concept of applying technology to solve problems and satisfy needs and wants, aims to develop individuals' knowledge, skills, attitudes and values in order to maximizing their adaptability and flexibility for future employment. As a field of study, technology education was internationally recognized in the 1980s, but the history of teaching craft-based and skill-oriented subjects in secondary schools in Hong Kong began in the 1920s. Students at that time were simply needed to acquire basic technical skills and gain practical experience to prepare for earning a living. Not until the mid-1970s was the higher order design element integrated into the curriculum of the local technology education to provide students with opportunities to practise problem-solving skills. Now, technology education is a part of general education in Hong Kong. In alignment with the global education trend, by combining science, technology, engineering and mathematics education, STEM education is currently being highly promoted in local schools. Besides, sustainability is a global issue of immense importance. Hong Kong, like many other cities in the world, has implemented various strategic measures to achieve sustainability. Theoretical perspectives on sustainable development under three topics, namely value position, nature of the proposed responses and structure of the proposed responses to this issue, as suggested in the literature, revealed that technology education can effectively contribute to education for sustainable development (ESD). A coherent and cross-curricular approach across all STEM subjects can be adopted in local secondary schools for ESD. This paper reviews the trends and challenges of technology education and STEM education in Hong Kong, discusses overseas experiences on integrating ESD through technology education into the school curricula, and describes case studies in the context of STEM education for introducing green design and green products as recommended in the literature to be beneficial to the future ESD.

Keywords: *technology education, STEM education, values, problem-solving skills, trends and challenges, sustainability, education for sustainable development*

Introduction

According to ITEA (2000), technology is defined as human innovation in action that involves the generation of knowledge and processes to develop systems for solving problems and extending capabilities. Technology education is a part of general education that is designed to develop technological literacy among students. The ultimate goal of technology education is to produce students with conceptual understanding of technology and its place in the society and thus grasp and evaluate new bits of technology that they may never have seen before. The definition of technological literacy is given as what every person requires to become an informed and contributing citizen for the present and the future. The scope and nature of technology education however vary in different places. In Hong Kong, technology education since 2015 has officially been integrated into STEM education, which is an acronym that stands for the academic disciplines of science, technology, engineering and mathematics collectively. This paper reviews the trends and challenges of technology education as well as STEM education in Hong Kong.

The concept of sustainability has sparked intense international debates since the early 1980s. Governments and non-government organizations all over the world have become aware of and expressed concern about the future of the mankind. The discourse took a pause when a common description of sustainable development was agreed: sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The discussions about how sustainability can be achieved across a community however never stop.

Different cities empathize different areas and set out different ways for approaching sustainable development. In consideration of the strategic direction of Hong Kong, three areas were identified to exert impacts on the city's sustainable development. They are namely solid waste management, renewable energy and urban living space. Extra efforts are paid on these three areas in order to achieve sustainable development in the city.

One of the most crucial meanings of education is to empower people to contribute to environmentally sound sustainable development through their lives and careers. Whatever sustainable development is conceptualized, there is always a general agreement that education plays an essential role in this issue. As reported in the literature, theoretical perspectives of three areas: value position, nature of the proposed responses and structure of the proposed responses towards the issue, provide a clear interpretation of sustainable development. Launching education for sustainable development (ESD) through technology education is highly preferred because it has the particular capabilities for developing a moral value and solving authentic problems by using practical solutions and innovation designs. This paper discusses overseas experiences on establishing ESD based on technology education, and describes two case studies in the context of STEM education about promoting green design and green products which were suggested in the literature that they are highly effective to the future ESD.

Trends of Technology Education in Hong Kong

Technology education as a field of study was widely recognized by the end of the 1980s but the inclusion of technology education in the secondary school curriculum began much earlier. The teaching of traditional technical subjects in schools in Hong Kong can be traced back to as early as the 1920s (Feng, 2012). As a British colony at that time, the local education system was primarily modelled on that of the United Kingdom. Technology education at that time was mainly, formally offered at the secondary level. The title of these technical subjects, e.g. woodwork and metalwork, revealed that students at that time were only required to acquire simple technical skills and gain basic work experience for the preparation of earning for their own. Besides, the curricula of most traditional technical subjects in Hong Kong were copied directly from those used in the earlier days in the British schools, and had not been revised for many years.

In the late 1970s, Hong Kong economy undertook a major transformation, from manufacturing industry to services industry. To adapt to the changed economy, in the education system, a subject of different nature called Design and Technology (D&T) was introduced at that time to the junior secondary level as an attempt to get out of the traditional craft-based and skill-oriented subjects. This subject incorporates higher order design element into the local technology education curriculum, focuses on the thinking process and involves more design and problem solving components than any traditional technical subjects did. The intended learning outcome of this subject is that by the end, students should be able to obtain technological literacy through the development of design and technological understanding, knowledge and capacity, communication and problem-solving skills, and awareness of the relationship among design, technology and the society (CDC, 2015).

D&T provides a new direction in learning and a new learning environment for students such that they can have more chances to practise problem-solving skills. The reinforced subject of D&T, called Design and Applied Technology (DAT), was later made available for the senior secondary students. The success in developing D&T and DAT triggered the reconstruction of the other traditional technical subjects and the development of new technical subjects containing more design and problem-solving elements in the early 1980s. However, there was no more major modification in the local technology education over the following 20 years.

Challenges of Technology Education in Hong Kong

Before the year of 2000, all the technical subjects in the local technology education curriculum still remained using outdated teaching materials and teaching methods. The situation had a change in 2000. In order to match up to another economic transformation towards a financial centre, the "Reform Proposal for the Education System in Hong Kong" prepared by the Education Commission of the Hong Kong Government proposed that all the subjects in the curriculum should be reorganized and categorized into Key Learning Areas (KLAs) (CDC, 2015). Technology education is one of the KLAs.

Table 1 shows the existing technical subjects in the technology education curriculum at the secondary level in Hong Kong.

Table 1. Technology education at the secondary level in Hong Kong (CDC, 2015)

Junior secondary (Secondary 1-3)	• Automobile Technology • Business Fundamentals • Catering Services • Computer Literacy • Design & Technology • Design & Technology (Alternative Syllabus) • Design Fundamentals • Desktop Publishing • Electronics & Electricity • Fashion Design • Graphical Communication • Home Economics/ Technology and Living • Retail Merchandising • Technology Fundamentals
Senior secondary (Secondary 4-6)	• Business, Accounting and Financial Studies • Design & Applied Technology • Health Management and Social Care • Information and Communication Technology • Technology and Living

For junior secondary level, the latest curricula of the technical subjects in the local technology education were released in 2000 and implemented in the same year while those of the senior secondary level were released in 2007 and implemented in 2009, with minor updates in 2015. It is worthwhile to note that for D&T, the schools have a high degree of freedom to follow the curriculum of the 1983 version or that introduced in 2000. The objectives of the latest D&T curriculum at the junior secondary level are to help students to develop technological awareness, literacy, capability and lifelong learning patterns (CDC, 2015). The curriculum can broadly be divided into four areas of learning: nature and impact of technology for yesterday, today and tomorrow, tools and machines of technology, resources of technology, and design and communication. As for DAT at the senior secondary level, the objectives of its latest curriculum issued in 2015 are to provide students with fundamental knowledge and skills in design and technology and to cultivate them the attributes of innovation and entrepreneurship necessary to face the rapid social, economic and technological changes in a knowledge-based economy (CDC, 2015).

Over the past 30 years, technology education in Hong Kong has changed from skill-based teaching to teaching and learning for a balanced development of technological capability, understanding and awareness. Technology education provides broader chances to cultivate students' initiative, creativity, problem-solving skills and practical design competence. Technology education has developed to a high level between 1970s and 2000s in Hong Kong (Volk, 2003), but in the recent decade, the shift of the economy to finance and banking has caused technology education to struggle in a difficult situation. Besides, technology education is not officially offered as an independent curriculum at the secondary level in Hong Kong. Neither D&T at the junior level or DAT at the senior level nor any other technical subjects in the current technology education curriculum is recommended to be compulsory in the local secondary education system. Technology education in some local secondary schools has started to be cut back, suspended or closed, which leads to a significant decline in the number of students studied in the technical subjects. Today, only half of the local secondary schools offer D&T and less than 40 schools offer DAT (Feng, 2012). A comprehensive review of technology education in the local curriculum is therefore in great need.

STEM Education in Hong Kong

In Hong Kong, currently, there are eight KLAs in the school curriculum, namely Chinese language, English language, mathematics, science, technology, personal, social and humanities, arts and physical education. Every student should gain a balanced exposure in all these eight KLAs (CDC, 2015). However, when an educational system cannot satisfactorily achieve its goals, government and citizen groups will call for an educational reform.

In order to maintain the international competitiveness of and create opportunities for Hong Kong in national developments, the Hong Kong government is currently actively promoting innovation and technology across the city (CDC, 2015). Talents with different capabilities, at different levels are required to fulfil and contribute to the economic, scientific and technological developments of the city and the country. Although Hong Kong students perform well in science, technology and mathematics in international competitions, it has been criticized that they may focus only on individual disciplinary studies but not evenly participate in hands-on activities in schools. On the one hand, the current education curriculum may have failed to arouse all the abilities of students to solve daily life problems. On the other hand, it is widely agreed that knowledge learnt through the school subjects of science, technology, engineering and mathematics are most useful for people to live their everyday lives. Thus, a pedagogy, developed based on technology education and combined with science, mathematics and engineering education, is currently in need to strengthen the abilities of students in integrating and applying their knowledge and skills that they have learnt from different academic disciplines to provide practical solutions and innovation designs for their daily life challenges (CDC, 2015).

In 2015, when the school curriculum is under review, STEM education is notably introduced. The promotion of STEM education in Hong Kong is in alignment with the worldwide education trend. STEM refers to four subject disciplines, namely science, technology, engineering and mathematics. The differences between STEM education reform and other educational reforms rest upon three key factors: (i) STEM education responds to the worldwide economic challenges that many nations face; (ii) STEM education recognizes the demand for STEM literacy for solving the worldwide technological and environmental problems; and (iii) STEM education gives emphasis to the necessary knowledge and workforce skills required in the 21st century (Bybee, 2013).

The main objective of STEM education is to nurture students to equip with necessary knowledge, generic skills, values and attitudes in order to meet the increasing changes and challenges, and become effective lifelong learners. STEM education in Hong Kong is specifically intended to promote students' interest and develop their capacities to innovate by enhancing their creativity and problem-solving skills, through integrating and applying knowledge and skills across disciplines in solving real problems and promoting good citizenship. It also assists students' further studies and career planning, and allows teachers of different KLAs to work closely to enhance the overall learning and teaching effectiveness together. It is hoped that by adopting STEM education in local schools to nurture diversified talents of different capabilities can enhance the international competitiveness and social and economic development of Hong Kong.

STEM education is currently being highly promoted among schools in Hong Kong in a holistic and coherent manner through a variety of strategies, such as renewing the KLAs in the existing curricula of science, technology and mathematics education, enriching students' learning activities, strengthening project and experiential learning, providing teaching and learning resources, enhancing the teachers' professional development, partnering with key players in the community, and conducting reviews while disseminating good practices.

Besides, when promoting STEM education, five basic principles were identified by the Government for schools to follow. The ideas of these principles are summarized as follows: Each school is directed to build up on its own strength to provide students with STEM-related learning activities, diversified learning, teaching and assessment strategies in the way of continuous development process to answer students' needs and interest, where the learning activities and teaching strategies are most appreciable if they can balance the purposes, views and interests of the students and teachers and provide learning opportunities beyond classroom to the students so as to form a part of the essential student learning experiences (CDC, 2015b).

While STEM education is going to be adopted in local schools, five common confusions about STEM education must be highlighted: (i) it is not equal to a single scientific investigation; (ii) it is not equal to a single mathematics, science or technology competition; (iii) it is not equal to simply applying technology in the teaching of science or mathematics; (iv) it is not only suitable for a small group of elite science or mathematics students; and (v) it should be taught in an integrated, cross-circular manner, not just within the individual STEM subjects (Dugger, 2010).

The promotion of STEM education in Hong Kong started in 2015. It should take longer period of time to observe whether the outcomes of this new pedagogy can be effectively achieved.

Technology Education and Sustainable Development

Technology education is suggested to be an effective method of vocationalizing schooling. It is understood as developing an individual's capabilities and competences to empower the individual for his/ her future employment. One of the key features that appears to be common across technology education is the emphasis on problem solving.

Human has been living beyond the carrying capacity of the planet. Continuous degradation of the environment is adversely affecting the growth and development of our world. The future of the mankind and the quality of life for future generations are under threat. The concept of sustainable development emerged in the early 1980s as an attempt to bridge the gap between environmental concerns about the increasingly evident ecological consequences of human activities and socio-political concerns about the persistence of human development (Robinson, 2004). Measures are required to deal with this immensely important problem.

Education can make a significant contribution to the promotion of sustainable development. Sustainability is often described in curriculum documents as an issue that is intended to be integrated within design projects and activities, rather than being a lesson topic in a classroom (Middleton, 2009). Owing to the particular emphasis on problem-solving skills, in the recent decade, the issue of sustainability has been linked with technology education.

Pavlova (2009) studied the theoretical perspectives on sustainable development under three key areas: value position, nature and structure of the proposed responses towards the sustainable development issues.

When interpreting sustainable development comes to value position, the first question is often whether human should put more emphasis on human or the nature. There are frequent debates on philosophical and moral concepts of appropriate methods to conceive of the relationship between human and the nature. Huckle (2005) criticized that ecocentrism, i.e. the environmental ethics that human should live with reference to the nature, romanticizes the nature outside the society and fails to recognize that only human can value things; while if anthropocentrism, i.e. the environmental ethics that the nature should be used and managed, is too strong, it will allow the exploitation and oppression of the nature by treating it instrumentally or only as a means to human. Pavlova (2009) suggested that a weak anthropocentric approach that promotes mutual flourishing of human and the nature should be adopted as the value position to conceptualize sustainable development in order to provide a basis for education for sustainable development (ESD) via technology education.

As for the nature of the proposed responses towards sustainable development, Robinson (2004) identified two major approaches, i.e. technical fix and value change. It was highlighted that these two approaches of responses should be conducted in parallel. One major reason is that although technology has plenty of positive features for achieving sustainability, technological advancement is a subject of profitability. In economics, the Jevons Paradox teaches us when technological progress increases the efficiency with which a resource is used, reducing the amount necessary for anyone use, but the consumption rate of that resource rises due to the increasing demand. It is easily understood that achieving reductions in the environmental impacts of an economic activity does not necessarily translate into improvements in human living quality. The major goal of the responses to sustainable development is to achieve optimal performance by using the technological problem-solving skills with a change of the value learnt from technology education.

The responses towards sustainable development may contain several common goals or themes. With regard to the structure of the proposed responses, Pavlova (2009) responded to the three key areas of concepts for ESD, as identified in the International Implementation Scheme for the United Nations Decade of ESD, which are society, environment and economy. The three concepts establish the framework of ESD. Since these elements comprise an ongoing and long-term process of change in knowledge, skills, moral values, attitudes and behaviours, it is worthwhile to remark that achieving sustainable development is a dynamic action.

Theoretical perspectives that include value position, nature and structure of the proposed responses provide a clear interpretation of sustainable development. A weak anthropocentric approach together with an emphasis on value change and the issues on the ever-changing society, environment and economy build up the nature of ESD. Technology education which has the particular value and design and problem-solving components can effectively contribute to ESD. Currently as technology education is fused into the STEM education in Hong Kong, a coherent and cross-curricular approach across all STEM subjects can be adopted in local secondary schools for ESD.

Overseas Experience on ESD

The need to integrate ESD into technology education has taken on a new priority internationally in recent years. Governments of many countries in the world are working hard to include ESD in their curriculum documents. This paper overviews the experiences of the governments in Australia, Ireland and Sweden on promoting sustainable development through technology education.

Currently, there are two syllabuses about technology being used in Queensland, Australia (QSA, 2007). Both syllabuses have the requirements of delivering some ESD elements to the students. The junior students are required to work technologically and consider appropriateness in the social, environment and economic aspects before adjudicating on the sustainability of their design ideas, the processes and the products as well as their possible impacts on the users or the environment. During the process, appropriate knowledge, practices and attitudes can be developed in the students. This syllabus provides teachers with an opportunity to introduce the basic ideas of sustainable development. However, no guidelines on the concept about appropriateness leads to no mechanism to evaluate the education effectiveness of the teachers and students on ESD. This situation was criticized that in the context of the outcome-based education, the majority of teachers would not pay much attention to the sustainability aspect of the syllabus (Pavlova, 2009).

In the Irish education system (IESD, 2006), younger students study in the Junior Certificate programme, in which four technical subjects are elective. Material Technology, Technical Graphics and Metalwork do not have any element about technology and society. The remaining technical subject Technology was developed as a combination of the other three technical subjects but having a strong emphasis on the design and problem solving skills. The concern on the relationship between technology and society also features the syllabus. As for the senior level, the technical subject Technology and Society provides a context in which students can explore and appreciate the impact of past, present and future technologies on the economy, society and environment. Critiques however appeared around the Irish technology education. It was argued that although the focus of the technical subjects has moved from a craft-based model to a design-based model, simple passing-on of traditional knowledge and skills to students remains. Students are not required to understand the content (Owen-Jackson, 2000). While Technology and Society shows awareness of the environmental issues, the other subjects appear to operate without a real understanding about the complex economic and social effects that shape the technological development. The absence of a focus on these effects of technology on sustainable development across the suite of the Irish technology education also highlights a significant failure in ESD (McGarr, 2010).

In the current Swedish school curriculum, ESD is a requirement (SNAE, 2011). It is highlighted that every person working in the school should encourage respect for the intrinsic value of each person and the environment. In the Swedish education system, environment is one of the four perspectives, which states that teaching should illuminate how the functions of society and our ways of living and working can best be adapted in order to create sustainable development. Three goals in the curriculum are sustainability or a sustainable development approach. It is mentioned that the school is responsible for ensuring that each student on completing compulsory school has obtained knowledge about the prerequisites for a good environment and sustainable development. Sustainable development is explicitly written out as an important element in the syllabuses of eight subjects. In the subject of Technology, for example, its goal is clearly related to sustainable development: students should be given the preconditions to develop confidence in their own ability to assess technical solutions and relate these solutions to sustainable development. However, this curriculum of ESD also has shortages. It was criticized that knowledge about sustainability in the Swedish technology education is vague and teachers are mainly aware of the ecological and environmental aspects of sustainability but less on the social or economic parts (Inga-Britt, Gumaelius and Geschwind, 2013). Besides, the implementation process of ESD was complained since decisions and directives of ESD is taken at the organizational level with few chances for teachers to influence the what, when and why of ESD.

In looking back at the experience of integrating ESD into the school curricula in Australia, Ireland and Sweden, four strategies for developing ESD successfully in Hong Kong are proposed, (i) an audit should be conducted on the syllabuses of all the technological subjects to avoid sustainability blind spots; (ii) the assessment methods should align constructively with the intended learning outcome and the nature of the learning activities to enrich ESD learning experience; (iii) professional development opportunities should be offered to teachers for ESD; and (iv) a constant evaluation mechanism for ESD is needed (McGarr, 2010) .

Suggested Learning Strategies in the Context of ESD

The importance of ESD can be addressed via STEM education in Hong Kong. Case studies are usually good starting points for students to understand, analyse and brainstorm solutions for a daily life problem. Learning activities in ESD suggested in the literature for realizing green strategies and technologies are described.

Various problem-solving strategies can be used in the green design. Advanced Systematic Inventive Thinking (ASIT) is one of the strategies, which contains five tools: unification, multiplication, division, breaking symmetry and object removal.

A case study was proposed about a management company requiring a sustainable design to solve the problem of disposing sewage. Students can propose their own solutions to the above challenges with the basis of the knowledge they have learnt from the STEM subjects. For example, students can combine the knowledge learnt from Science with the ASIT tools of unification and division to assign worms a new use to break the sewage down to become humus. Students can combine the knowledge learnt from Technology with multiplication tool to slightly modify the existing worm farm technology to minimize the use of energy consuming power machines or probably toxic chemicals but deal with the sewage naturally. They can use the knowledge learnt from Engineering to speed up the rate of natural transformation. They can also use the knowledge learnt from Mathematics to determine the reduction of daily running costs, the negative costs to the environment as well as the ongoing maintenance costs. This ESD of green strategies in this way will create a win situation for all the parties, customers, students and the environment.

Different criteria for green product design have been developed all over the world, such as Datschefski's five principles of designing sustainable products, which require: (i) the products are made from organic materials and is recyclable or compostable; (ii) the products should use solar energy or other forms of renewable energy during manufacture and use; (iii) the products must be non-toxic in making, use and disposal; (iv) the products should consume less materials, energy or water; and (v) the products should be made under fair and just operating conditions for the workers and the communities involved.

A case study was proposed about an industry which recognizes the challenges posed by energy shortages, climate change and the necessity for energy efficiency in buildings. A green product is needed to reduce the energy consumption of the industry. Similarly, students can propose their own solutions to the above challenges with the basis of the knowledge they have learnt from the STEM subjects. For example, students can use the knowledge learnt from Science to identify, source and use new and more efficient materials for the green product to reduce energy consumption. They can use the knowledge learnt from Technology to design the green product to consume renewable energy instead of fossil fuel energy and consume less materials and water. They can use the knowledge learnt from Engineering to improve the energy efficiency of the green product. They can also use the knowledge learnt from Mathematics to evaluate the effectiveness of energy saving by using their green product across the industry.

At the end of the ESD class, teachers can introduce more methodologies of assessing environmental impacts of the existing and new products, e.g. Life Cycle Analysis (LCA). When LCA is applied in the ESD teaching, issues such as energy and water consumption, toxic emissions, transport problems and the health and safety of users and workers can be further discussed (Pavlova, 2009).

Conclusion

There are three aims of this paper: (i) to review the development and challenges of technology education and STEM education in Hong Kong; (ii) to study the overseas experience in integrating ESD via technology education into their school curriculum; and (iii) to describe some case studies that were proposed in the literature about the adoption of STEM education in promoting ESD.

Technology education began in the 1920s in Hong Kong. By integrating higher order design element into the curriculum, technology education becomes a part of general education for our students. In alignment with the global education trend, the local Government is pushing STEM education. Besides, sustainability calls for the global concern. Hong Kong has established a strategy direction for mitigating a number of environmental problems. Human resources with different capabilities at different levels are required to help to achieve sustainability in Hong Kong. Literature reveals the support of theoretical perspectives on sustainable development under value position, nature and structure of the proposed responses on technology education for its contribution to ESD as it provides a set of clear priorities for teaching and learning. Therefore, a coherent and cross-curricular approach across all STEM subjects can be adopted in local secondary schools for ESD.

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