Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry

by

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A Thesis Submitted to

The Education University of Hong Kong

in Partial Fulfillment of the Requirement for

The Degree of Doctor of Education

March 2021

Statement of Originality

I, HWONG, Yau Hung Benny, hereby declare that I am the sole author of the thesis and the material presented in this thesis is my original work except those indicated in the acknowledgement. I further declare that I have followed the University's policies and regulations on Academic Honesty, Copyright and Plagiarism in writing the thesis and no material in this thesis has been submitted for a degree in this or other universities.

Abstract

Technical and Vocational Education and Training (TVET) is the essential route to supply feeders to sustain the economy and industry of a country. The context of vocational education and training plays an important role to meet the demand from industries, especially under the recent advocacy of science, technology, engineering, and mathematics (STEM) in the curriculum, which is believed to be the best pedagogy to enhance learning and teaching. This thesis investigates the effectiveness of STEM activities embedded in TVET for a sustainable fashion textile and clothing industry and proposes an improvement plan for reference.

As an author as well as the principal investigator of this research study, he designed the entire experiment during the field study, set up treatment classes, established the research methodology, collected, and analyzed data and provided all conclusions. Insights and implications have also been gained and adopted for the improvement and future development of TVET. Hence, "STEM-VET" might be seen as a major innovation focusing not only on trainees needs today, but 'setting the scene' for lifelong learning which is part of preparation for enabling the sustainable development in the industry of tomorrow.

During the research study, the principal investigator adopted the mixed method approach (qualitative and quantitative) and triangulation to investigate the interrelationship among STEM activities, TVET and a sustainable fashion textile and clothing industry. There were three treatment classes with STEM activities embedded for investigation during the 7-month research period. The results and findings collected from participants (industry representatives, TVET trainers and TVET trainees) reflected that STEM activities can enhance the learning process and benefit TVET to ensure the sustainable development goals in the industry. The research design provided triangulation from the views of TVET trainee participants who conformed the comments from the industry representatives as well as TVET trainers during the interviews.

Overall, all research questions stipulated in this project have been addressed, and findings as well as insights have been solicited and recommended to improve TVET. STEM activities embedded in TVET are definitely beneficial to ensure a sustainable fashion textile and clothing industry towards sustainable development (SD).

Keywords: curriculum, industry, STEM (Science, Technology, Engineering, Mathematics), STEM activities, sustainable development, technology, TVET (Technical and Vocational Education and Training)

Acknowledgements

Hereunder are the organizations which have rendered contributions and supports in the research project, and the author is very grateful to acknowledge them for keen supports which facilitated the collection and processing of the data during the research period with no priority meaning in the list below. Furthermore, the author would like to express his sincere gratitude to his principal supervisor Professor Yeung Yau Yuen and associate supervisor Associate Professor Tsang Yiu Fai for their professional advices on this research study. Last but not least, special thanks to Manson Fred Hwong for the support in edit of this thesis.

- Classic Anew Fashion Workshop
- Clothing Industry Training Authority
- Education University of Hong Kong
- Glorisun Enterprise Limited
- Hong Kong Federation of Trade Union – The Spare Time Study Center
- Hong Kong Polytechnic University
- Hong Kong Wearing Apparel Industry Employees General Union
- International Fashion Design Management Association
- Kalico Design Limited
- Kurabo Industries Limited
- Sew On Studio
- The Woolmark Company

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List of Abbreviations

ApL – Applied Learning
CITA – Clothing Industry Training Authority
ESD – Education for Sustainable Development
FTC – Fashion Textile and Clothing
HKFTU – Hong Kong Federation of Trade Unions
HKSAR – Hong Kong Special Administrative Region
HKWAIU – Hong Kong Wearing Apparel Industry Employees General Union
ICT – Information Communication Technology
MOI – Medium of Instruction
NGO – Non-Government Organization
NSS – New Secondary School
OBM – Original Brand Manufacturing
ODM – Original Design Manufacturing
OEM – Original Equipment Manufacturing
OLE – Other Learning Experience
PBL – Project-based Learning
PbBL – Problem-based Learning
PDCA – Plan-Do-Check-Act
RTTP – Reindustrialization and Technology Training Program
SES – STEM Evaluation Scale
SCS – Specification of Competence Standards
SoW – Scheme of Work
STSC – Spare Time Study Center
STEM – Science, Technology, Engineering, Mathematics
TEL – Technology Enhanced Learning
TTR – Trainer
TRR – Trainee
TVET – Technical and Vocational Education and Training
TWC – The Woolmark Company
WIL – Work Integrated Learning
UNESCO – United Nations Educational, Scientific, and Cultural Organization
VET – Vocational Education and Training
VPET – Vocational and Professional Education and Training
VM – Visual Merchandising
VR- Virtual Reality
VTC – Vocational Training Council

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Chapter 1 Introduction

(Why the research has been undertaken)

1.1 Background

Globalization results in both pressure and drivers for all countries and enterprises in the world that are trying to improve their environmental performance. Environmentally friendly (also eco-friendly, nature friendly, and green) are terms used for referring goods and services, laws, guidelines and policies claiming to inflict minimal or no harm on the environment (Eryuruk, 2012). This seems related to matters of science and technology (S and T in acronym STEM) during the process in goods production and service provision. Moreover, the bloom of STEM education and training in the 21st century has been largely observed in many countries such as United States of America, Europe and United Kingdom. Technical and Vocational Education and Training (TVET) has been gaining its popularity and contributes to sustainable development (SD), especially on the sustainable environmental development and including green jobs (AIP Conference Proceedings 1887, 020076, 2017). Henceforth, it is interesting and worthy to carry out the research to investigate the interrelationship of the four domains: STEM, TVET, FTC industry and SD, and find out how STEM through TVET address to the SD in FTC industry respectively.

The acronym STEM possesses quite a broad definition, National Science Foundation (NSF) includes not only the common categories of mathematics, natural sciences, engineering, and computer as well as information sciences, but also such social/behavioral sciences as psychology, economics, sociology and political science (Green, 2007). Across the world STEM (learning and work in Science, Technology, Engineering and Mathematics) has taken central importance in education and the economy. STEM competence has become seen as key to higher productivity, technological adaptation and research-based innovation

(Freeman, Marginson & Tytler, 2015). Sanders (2009) mentioned a review of the literature over the past 10 years revealed that STEM evolved out of government policy, especially from within the NSF, and NSF first used the acronym SMET for science, mathematics, engineering, and technology in the early 1990s, but determined that this acronym would cause issue of vulgarity, therefore, SMET was changed to STEM. Originally, it was created by the NSF as an educational initiative to provide all students with critical thinking skills which would help them to resolve problems innovatively and become more marketable in the workforce.

Recently, the STEM education has been referred to the teaching and learning of science, technology, engineering and mathematics; it typically encompasses all educational activities implemented across all grade levels, from pre-school to post-doctorate in formal and informal classroom settings (Gonzalez & Kuenzi, 2012). Bybee (2013) mentioned that the ultimate purpose of STEM education is to further develop a STEM-literate society. One of his definitions of 'STEM literacy' refers to an individual's attitudes, knowledge and skills to identify questions and problems in real life situations, explain the nature of the world, and draw evidence-based conclusions about STEM-related matters. Research in STEM learning over the past two decades has a lot to say about what makes for effective, engaging STEM education. Amongst the key factors: it capitalizes on students' early interests and experiences, identifies and builds on what they know, provide them with opportunities to engage in the practices of science and mathematics so as to sustain their interest as well as investigate questions about the real world across their daily lives (Cadre, 2012).

Actually, there is no single definition about STEM, it can be conceived as a set of interrelated disciplines and required skills including but not limited to numeracy and digital skills. And STEM education and training aims not only to develop expertise and capability in individual field, but also to enhance the ability to work across disciplines in generating new ideas, knowledge and products which involved problem-solving as well as collaboration across fields and disciplines (Education Scotland, 2017). Furthermore, Bryan, Moore, Johnson and Roehrig (2015) stated that 21st century skills encompass creativity, critical thinking, problem-solving, communication and teamwork building. The definition of the STEM fields are as follows. *Science* is the systematic study of the nature and behavior of the materials and physical universe. It relies on observations, experiments, and measurements, followed by formulation of rubrics to describe all these groundings in general terms (Science, 2012). *Technology* is the branch of knowledge that is concerned with the creation and use of technical methodology, and its interrelation with human's daily life, society and the environment. This field also draws upon subjects such as industrial arts, engineering, applied science, and pure science (Technology, 2012). *Engineering* is the art or science of using practical application of the knowledge of pure sciences, such as physics or chemistry, in the construction of engines, buildings, flyovers, ships, and chemical mills (Engineering, 2012). *Mathematics* is a group of related sciences that embraces geometry, algebra and calculus; these fields study numerical figures, quantities, shapes, and forms as well as their inter-relationships using a specialized notation (Mathematics, 2012).

Based on the definition by the United Nations Education, Scientific and Cultural Organization (UNESCO) and the International Labor Organization (ILO), Technical and Vocational Education and Training (TVET) refers to 'aspects of the educational and training processes involving, in additional to the general education which encompassing the study of technologies and related sciences, together with the acquisition of practical skills, attitudes, understanding and knowledge relating to occupants in various sectors of economic and social life' (UNESCO and ILO, 2002).

First, UNESCO and ILO (2002) mentioned that TVET is further understood to be the means of preparing individuals for occupational fields and effective participation in the world of works. Second, it enhances lifelong learning and prepares individuals for responsible citizenship. Third, it acts as an instrument for promoting environmentally sustainable development and acquisition of knowledge and skills for the world of work. All these can be seen in vocational education, technical education, apprenticeship training, occupational education (OE), technical-vocational education (TVE), vocational education and training (VET), professional and vocational education (PVE), workplace education (WP) and career and technical education (CTE), among others, in different geographic areas around the world.

By referring to the recent global education and training landscape, STEM education has been highlighted across various disciplines. In the Hong Kong Special Administrative Region (HKSAR), the government has highlighted the importance of embracing an initiative to foster STEM for the sustainability of intelligent people, living, management, mobility, economics and environment within a smart city (Government of HKSAR, 2017). A successful smart city under the eco-concept requires a knowledgeable and sustainable skilled workforce in the areas of science and technology, which are the key elements found in STEM, and STEM is the crucial driving force for an economy's and a society's needs that lead to better ways of living. TVET is the key player to provide feeders to STEM careers, and thus STEM education and training plays an essential role in strengthening trainees' ability to integrate professional knowledge and skills across different disciplines as well as to nurture their creativity, collaborative abilities and problem-solving skills with an innovative and entrepreneurial spirit in the smart city (Heaver, 2017).

An industry is a group of companies that are highly related to common primary business activities (Industry, 2003). It is an important sector that produces goods or related services within a country's economy. The Industrial Resolution – from Industry 1.0 to 4.0 – represents the evolution of global industry. Industry 1.0 commenced in the 1780s; it used water and steam power in mechanization. Industry 2.0 involved electrical power in mass production, while Industry 3.0 consisted of automation and computerization. Industry 4.0 refers mainly to the data exchange in manufacturing technologies encompassing cyber-physical systems, the Internet of things (IoT), refers to all physical devices around the world that can be connected to the internet for data collecting and sharing normally via the wireless networks, likewise homes and offices are using Wi-Fi, Zigbee, Bluetooth or LTE and so on (Ranger, 2000), big data and analysis, virtual reality (VR) and augmented reality (AR) simulation as well as autonomous robots and cloud applications. All these new elements in technologies combine with intelligent machines and fit into all processes, from design development to manufacturing, to build up a new and high-value supply chain (Tay, Lee, Hamid, & Ahmad, 2018). Last but not least, industry acts as a catalyst, with elements of embedded technology, to boost the economy and sustainability in the country.

1.2 Objectives

In the 21st century, most industries have been evolving from a traditional labor-intensive mode to a smart operative mode with support from advanced technology in achieving the eco-concept highlighted in environmental sustainability. Some examples are green technologies adopted in electrical vehicles and waterless dyeing and finishing adopted in the textile and clothing industries. STEM elements are crucial tools in TVET to steer and enrich the trainees towards knowledge, skills and competence-based outcomes as well as their applications in real-world contexts.

The aim of the research project is to study and investigate the interrelationship among STEM elements and activities in the TVET for a sustainable Fashion Textile and Clothing (FTC) industry in Hong Kong Special Administrative Region (HKSAR) with the goal to improve the teaching and learning methodology in TVET so as to enhance and upskilling the in-service practitioners' competence in the FTC industries. The idea is to move TVET forward to a more meaningfully relate to the sustainable development or promotion of a sustainable industry on tomorrow.

Under the umbrella of TVET in Hong Kong, one of the biggest stakeholders of TVET in Hong Kong is the Spare Time Study Center (STSC) under the Hong Kong Federation of Trade Unions (HKFTU); it comprises different trade and worker unions with various trades such as commerce, engineering, lifestyle and arts, tourism and hospitality, FTC and building and construction, among others. The other stakeholders in TVET include but not limited to the Vocational Training Council (VTC) and the Clothing Industry Training Authority (CITA) as well as relevant chambers and unions from the industry.

This project is an action research study, which is a kind of qualitative research that seeks actions and ways to improve practice as well as analyze the effects of actions that are taken (Streubert & Carpenter, 2002). The goal is to study and examine the current and future needs of the fashion textile and clothing (FTC) industry; how STEM activities can enhance TVET to ensure a sustainable industry; and to determine in what ways to implement STEM activities in TVET so as to enhance learning and teaching as well as to achieve effective outcomes that benefit in-service practitioners' overall performance. As such, STEM activities related to fashion and textile fields will be well designed and implemented in the in-service courses in the STSC of HKFTU and other organizations, worker unions as well as associations in order to collect and evaluate the data from the research study. The in-service training courses from those organizations, trade and worker unions as well as associations are chosen for this research study because they are the most representative with regard to trainees who normally come from different positions and sectors in the workplace of the FTC industry.

1.3 Research Questions

RQ1: What are the perspectives of Fashion Textile & Clothing industry representatives on STEM activities and TVET for in-service practitioners in Hong Kong? What are the current and future needs for the quality/ capacity of manpower? What are the main problems or deficiencies of the current in-service practitioners?

RQ2: What about STEM and how to implement STEM activities to enhance TVET in a sustainable Fashion Textile & Clothing Industry? What are the main difficulties or constraints for practical workshop implementation? What are the resources or facilities for full implementation?

RQ3: Is there any effectiveness in teaching and learning upon STEM activities infused in TVET? What are the industry representatives', instructors' and trainees' views, learning attitudes and receptivity towards those STEM activities? What are the effects on the trainees' overall performance?

1.4 Significance and Scope of the Study

Rapid transformations of societies in areas of political, social, economic and technological areas as well as education and training have altered the demand for vocational skills (Pavlova & Maclean, 2013). There has an obvious rise in the demand for STEM professionals due to the variety of STEM occupations in global markets. For instance, emerging green construction works and electric automobile production all require STEM professionals (Skaar, 2016). In addition, smart textiles encompass a variety of innovations that require technicians with STEM skills for their implementation and sustainability. For example, they may need to possess STEM knowledge and skills to develop a water repellent surface and wicking back of textiles that reacts directly to stimuli from the environment. The application of ozone technology (Figure 1) on textile environmental friendly pre-treatment as well as dyeing processes, the ozonation together with the ultrasonic washing which can save up tremendous water adopted in the traditional dyeing and washing processes. Also, 'laser-wash' technology (Figure 2) on denim jeans by the application of laser engraving method on denim product, white tones of "washing marks" have been engraved onto the upper part of denim jeans clearly when compared to the lower end without the application of laser technology. The application of this new technologies can save a lot of fresh water used in the traditional denim product dyeing, washing and finishing that goes in line with SD concept.

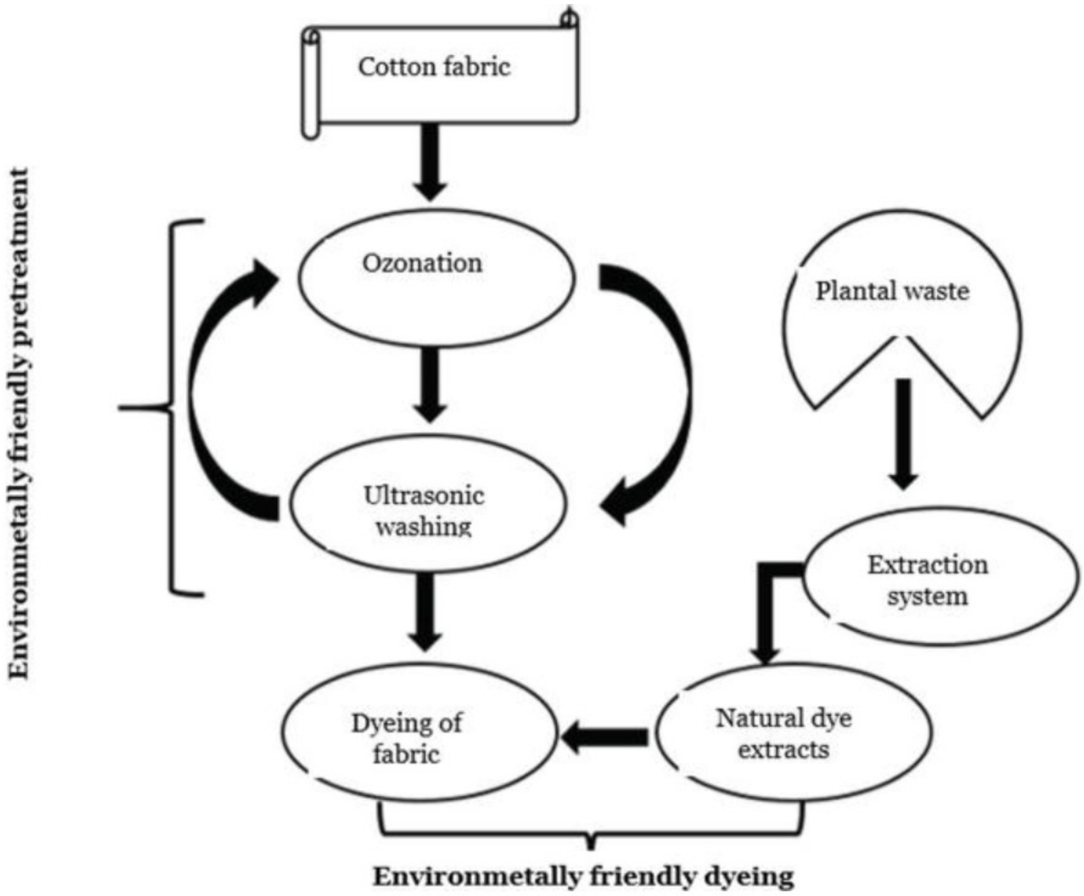


Figure 1. A diagram shows ozone technology for textile (pretreatment and dyeing) (open source in the website)

Figure 2. A picture shows the "laser-wash" technology applied to denim jeans

(open source in the website)

Thibaut et al. (2018) reflected that there is a general shortage of STEM graduates and some voices from relevant industries and also mentioned that the supply of technicians and technologists is not proportional to the industrial demand, which comprises STEM elements. Qualified STEM professionals are required to ensure an industry remains economically competitive in the global market; this position requires adequate and sustainable energy as well as well-considered technological development (Boe, Henriksen, Lyons, & Schreiner, 2011). Regarding this thesis's topic, very few research studies have evaluated the interrelationship amongst STEM, TVET and the sustainable FTC industry. Instead, many papers have examined STEM education in primary and secondary schooling. Mahoney (2010) also mentioned that there was very few research work done on how to improve learning by infusing STEM elements into the educational practice of K-12 schools; these approaches include creative inquiry, cooperative learning, group collaboration to solve problems in the real scenario under authentic environmental data and information.

Furthermore, Pavlova and Chen (2019) revealed an essential gap between pedagogical approaches put forward in the literature and the education for sustainable development pedagogical practices within the context of TVET in which STEM elements are greatly involved. From the archive information on STEM education for global leadership, on 23 March 2015, United States President Barack Obama announced that:

> Science is more than a college subject or a periodic table in chemistry or the properties of waves in physic. It was indeed an approach to the whole world, a critical way to understand, to explore and engage with the world, and then possess the capacity to change that world. President Obama had also announced a clear priority for the STEM education, he advocated that students must move from the middle to the top level of science and mathematics within a decade. (STEM: Education for global leadership, n.d.)

Given the global emphasis on the importance of STEM education and training, the role of TVET is to prepare future engineers, craftspeople and technologists to sustain the economic and industrial sectors in the society without scarifying the beauty of the nature. Hence, it is necessary to critically review training courses in TVET, especially how effective the STEM elements and activities are integrated into these courses so as to achieve the desirable outcomes in sustainable industries (Skaar, 2016).

Base on the above significant information, there is an existing knowledge gap and a good chance to investigate the current situation in the industry as well as examine how the effective of the STEM elements in TVET (STEM-VET) can contribute to a sustainable FTC industry.

The scope of this study is mainly concentrated on the TVET organizations located in Hong Kong, with the aim to investigate the current practice and examine how effective the implementation of STEM activities in TVET can benefit the FTC industry or any improvement plan determined as a result of the investigation that make contributions to the industry. The TVET organizations encompass but are not limited to those run by the government, trade chambers, worker unions, non-governmental organizations (NGOs) and private sectors, among others.

1.5 Thesis Outline

With reference to the literature review, industry voice and TVET landscape, this thesis focuses on understanding the needs from the current FTC industry and the main problems and deficiencies encountered by practitioners. This thesis also investigates how to implement STEM activities into TVET to enhance learning and teaching and documents the difficulties and constraints and resources required for full implementation. A mixed method (qualitative and quantitative) approach will allow principal investigator to investigate the effectiveness of STEM activities being infused in TVET, learning attitudes, receptivity as well as overall performance observed during the research study. In arriving at the conclusion, the principal investigator will propose an improvement plan for TVET curriculum development that embraces STEM pedagogy and activities.

Chapter one is mainly the introduction on why the research study has been undertaken. Laying down the significance and the aim as well as the scope of research, and idea of advancement in STEM-VET to promote a sustainable development in the FTC industry. Objectives has been explicitly stipulated and followed by set of specific research questions and sub-questions that need to be answered through the research study.

Chapter two is mainly the literature review on TVET, STEM education and training, SD and FTC industry, pedagogy and frameworks as well as theories underlying. It can render insights about practices in TVET, STEM education and training together with pedagogical approaches adopted and their interrelationship to the SD in industry.

Chapter three is mainly the concerning the conceptual framework, research design, methodology approach on data collection from participants, data analysis methods, instrument and tools used, validity and reliability in consideration of ethical issues. Also, a description on a pilot study of focus group for latter treatment classes' reference.

Chapter four is mainly the results and findings from the qualitative and quantitative data analysis. Data sourcing method has been clarified and coding system have been applied for categories and sub-categories classification as well as elaboration on the results followed by analysis of the data which includes qualitative data from interviews and participant observation together with the quantitative data from Likert scale questionnaire survey. Lastly, triangulation method is adopted to verify any conformity or check out disconformity from both qualitative and quantitative data.

Chapter five is mainly the discussion and interpretation on the findings and the analyzed results. How they can justify the overall validity and reliability of those results and respond to the research questions respectively. It also clarifies the role of the author in the research study and limitation during the research study as well.

Chapter six is mainly the conclusion and implications on issues like interdisciplinary collaboration, reindustralization, reskilling and upskilling, skills for future, so on and so forth. It is wrapped up by proposing an improvement plan on learning and teaching strategies as well a recommendation for STEM activities and further research.

The rest of the Chapters are references, author's biographies and appendices for reader's reference.

Chapter 2 Literature Review

2.1 Background

Given that the research project is to investigate the effectiveness of STEM activities implemented in TVET for a sustainable FTC industry, to start the research study systematically and reliably, a literature review on TVET, STEM education and training, FTC industry, SD and relevant educational theories has been carried out for reference and information. This will underpin the research design and methodology. Besides taking reference from journals, academic publications, and conference presentations, other up-to-date information can be obtained through websites, white reports, e-books, blogs, and so on to have a more comprehensive review.

Those comprehensive reviews encompass but are not limited to the TVET general landscape, practice in HKSAR, the lifelong learning path, STEM education and activities, pedagogy in education and training such as problem- and project-based learning, the technology-enhanced learning like the use of mobile devices, VR and 3D visualization in learning, and computer-based learning. Furthermore, references have been made on sustainable development; sustainable development goals; eco-concepts, practices and pollution issues from the FTC industry; shortage of skilled labor; traceability from end-users; green skills and technology application in the industry with the aim of soliciting insightful information to plan this research study. Those literature information have been illustrated in the following sections from 2.2 to 2.7.

2.2 Overview of Technical and Vocational Education and Training

The term TVET read as Technical and Vocational Education and Training was introduced in 1999 at the UNESCO second international congress held in Seoul on technical and vocational education as a vital means of facilitating poverty reduction and maximizing social and economic benefits to improve rural livelihoods and lives, particularly for poor and disadvantaged youth and women (The Himalayan Times, 2017). The “V” in TVET stands for vocational, and vocational training can be called career education, technical training or skills development that can also exist in types of formal education and training, informal learning, apprenticeship, on-the-job training and continuous development (Skillsportal, 2020). And because of the importance of preparing for the future labor force as well as tackling various socioeconomic and environmental issues, TVET has to play an essential role in SD (AIP Conference Proceedings 1887, 020076, 2017).

TVET has steadily becomes popular within global debates and government priorities for education as well as national development agendas (Marope et al., 2015). Furthermore, TVET is known as professional education, training and technical skill set development, which relates to a broad range of occupational fields, services and production. It is a part of lifelong learning and can take place at different college levels, which may lead to a professional qualification (UNESCO, n.d.). An argument on economic recession, such as the Asian financial crisis has delivered a global dimension to lifelong learning and reshaped the local education system, including working adult education, to meet the global market standards (Han, 2007). Besides the stimulus from the economic recession, social and technological advancement has also promoted lifelong learning in the contemporary era. This seems to be a global model for educational reform and has become an important initiative for national education strategies (Han, 2007).

Indeed, lifelong learning is a continuous supportive process that stimulates as well as empowers individuals to acquire necessary skills and knowledge that they can apply throughout their lifetimes with confidence, creativity, and enjoyment in all roles and circumstances as well as environments, as first announced in the First Global Conference on

Lifelong Learning, cosponsored by the American Council on Education (Duyff, 1999).

The main objective and direction of TVET are training and learning for various careers to satisfy the needs in the labor market (Field, Hoeckel, Kis, & Kuczera, 2009). To create awareness on sustainable development is one of the important initiatives that TVET institutions must do to enhance the SD concept and practices within society (AIP Conference Proceedings 1887, 020076, 2017). Moreover, many studies have addressed the issue on how to improve students' understanding about sustainable development, and how education for sustainable development should be integrated in the TVET curriculum to promote problem solving skills, creativity and innovative skills to meet the challenging industry (AIP Conference Proceedings 1887, 020076, 2017). For instance, the SD "6R" practices (reduce, reuse, renew, recycle, repair and rethink) at the school level can be enhanced by interschool initiatives like managing school garbage and tree planting programs.

According to UNESCO. (2019, January 17), education for sustainable development empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability, and a just society for present and future generations, while respecting cultural diversity. And education for sustainable development is a holistic and transformational education that addresses learning content, outcomes, pedagogy and the learning environment. It achieves its purpose by transforming the society. The learning content encompasses critical issues such as climate change, biodiversity, disaster risk reduction, sustainable consumption, and production. The pedagogy and learning environment include designing teaching and learning in an interactive approach, which is learner centered and enables exploratory, action-oriented, and transformative learning.

Rethinking the learning environments in physical and virtual online modes also inspires learners to act for sustainability. For the societal transformation, it empowers learners of any age, in any education setting, to transform themselves and their society, enabling a transition to greener economies and societies, equipping learners with skills for "green jobs," and motivating people to adopt sustainable lifestyles.

Finally, the learning outcomes are to stimulate learning and promote core competencies like critical and systematic thinking, collaborative decision making, and being responsible for present and future generations. The present author seconded this goal and thought it goes well with problem- and project-based, student-centered learning, which is necessary to face the real-world challenges of the 21st century. Brundiers, Wiek, and Redman (2010) mentioned that most of the education for sustainable development pedagogical frameworks that incorporate real-world problem-solving opportunities use problem- anäd project-based learning or the integration of them. In fact, there is no "correct" pedagogy for sustainable education; rather there is a broad consensus that it requires a shift toward active, participative, and experiential learning methods that engage learners and make a real difference to their understanding, thinking, and ability to act.

The staff at the University of Plymouth in UK identified five pedagogical elements to be adopted in the learning environment: (a) critical reflection that involves discussion, systematic thinking and analysis with the use of real-world examples; (b) project-based learning; (c) participatory learning, which emphasizes group and peer learning as well as experiential learning; (d) creative learning for future scenarios, using role play and real-world cases as well as problem-based learning; and (e) collaborative learning, which requires contributions from guest speakers and also uses work-based learning (University of Plymouth, n.d.). The present author agrees that these elements could be effectively implemented in a TVET course.

Work-based learning is similar to work-integrated learning (WIL) which also allows the principal investigator to think of the implementation in the TVET training, since learners may be able to get direct benefit from the authentic learning during the dynamic interaction with the technicians or industry experts along the learning process. Of course, this has to go with the well matched and designed TVET curriculum, with appropriate strategies on workplace training and assessment. By the way, it is beneficial that TVET can partner with industry to ensure the job relevance of learning (UNESCO, n.d.)

Actually, there is growing international recognition of education for sustainable development as an integral element of quality education and a key enabler for SD. The SD goals (United Nations, 2014) adopted by the global community for the next 15 years include education for sustainable development (UNESCO, 2020, March 4). Under social development, one of the elements is education which encourages people to participate in environmental sustainability and teaches them about the effects of environmental protection as well as the dangers and consequence if we cannot achieve the sustainable development goals.

TVET is one of the study paths that comprise the STEM elements of related sciences and technologies, acquisition of practical skill sets and competence to serve different sectors of economic and social life (UNESCO, 1999). Many countries are aware that TVET is one of the viable routes to pursue a successful career, uplifting the economy, people, and nation (Omar & Krauss, 2011; UNESCO, 2010). Moreover, it has been estimated that around 80% of occupations focus on the application of technical and vocational skills (UNESCO-International Project on Technical and Vocational Education [UNEVOC] & UNESCO-Institute of Statistics [UIS], 2006). King (1993) also mentioned that TVET should be emphasized in both education and practical training, and there should be a considerable variety of locations to pursue TVET, most likely in formal colleges, post-school vocational training institutes or even inside workplaces.

The TVET mission in the United States is to promote education and training about a career or education through work, depending on the regional labor demands. TVET is also known as CTE in the United States. The US strategy promotes links between secondary and postsecondary vocational programs to prepare students to transit from schools to careers as well as to enhance lifelong learning opportunities for youth and working adults (UNESCO-UNEVOC, 2014). The tech-prep programs in United States are examples of adjusting the traditional school-based vocational education to the changing conditions of a globalized economy. By combining high school and community college courses students are prepared to satisfy the growing demand for a broader knowledge base and problem-solving qualifications (Kreysing, 2001).

In Germany, TVET focuses on the dual-track system of vocational training. The German federal government is responsible for vocational training in companies, while the länder are accountable for vocational training in colleges or vocational schools; Germany comprises 16 länder, which play a part in the federation's lawmaking as well as management and also in European Union issues (ReferNet, 2012). A dynamic and modern apprenticeship is maintained through the combination of work-based TVET with institutional training in the dual track system (Lauglo, 1994; Lauterbach, 1994).

Within vocational training, the primary aim is to enable young people to acquire comprehensive vocational skills and competence to effectively fulfill their roles as employees (ReferNet, 2012). As mentioned in that report, in the dual track system, employers and trade unions play a central role in vocational training, which must meet the demands of the industry. In general, dual track system trainees attend part-time vocational college on one or two days per week, where they are taught and trained mainly on theoretical and practical knowledge in relation to their occupation (ReferNet, 2012). The key feature of the German TVET system is a close partnership among government, employers and trade unions, with the ultimate aim of rendering high-quality vocational education and training in a lifelong learning perspective (ReferNet, 2012). Indeed, the dual track mode of training has also been observed in VTC part-time day release programs which encourage trainees to work a couple of days during the week in the industry and return to school for one or two full-day professional knowledge training, which can enrich and enhance their overall learning experiences.

Australia's competence-based TVET training is highly recognized worldwide largely due to its strong focus on industry demand, skills application, scalability, and flexibility. Its key features are meeting the needs of industry and individual. Industry is involved at every step of the process, such as qualification development and training implementation. In fact, industry is one of the key stakeholders in the Australian vocational education and training system, which also claimed as industry-led VET model and sustainable skills has nearly twenty years in experience of shaping and maintaining the VET systems in Australia (Caggiano, 2018).

In the United Kingdom, which is a union of England, Scotland, Wales and Northern Ireland, the government has a policy of governing all types and levels of education, including TVET (ReferNet, 2013). The number of career roles that require high skillsets and education is increasing in the UK to fit the technologically advancing labor market. TVET commences early in secondary schooling; for instance, skills for work courses in Scotland at secondary colleges often occur in partnership with local tertiary colleges and employers to ensure a real context in the industry (ReferNet, 2013). The report also reflected that the UK has a high participation rate in adult education as well as continuing training of the workforce, which can be in the form of on-the-job or off-the-job training for employees in various industries.

Also, in a country like Scotland, "STEM-VET" has an important meaning of driving STEM elements through the vehicle of vocational education and training (VET), with the aims of inspiring youngsters and adults to study STEM, and to provide a better connection between STEM education and training as well as needs of the labor market. Henceforth, STEM education and training is a core part of the government's Curriculum for Excellence.

(Scottish government, 2017).

In the African countries of Botswana, Egypt, Ghana, Senegal, Seychelles, Tunisia, and Zimbabwe, TVET refers to a series of learning experiences relating to the world of work which might take place in a variety of learning contexts, embracing educational institutions and the workplace (Oketch, 2007). Moreover, TVET also includes informal learning that occurs out of the schoolyard. The education systems in Africa comprise four levels: primary education (6-8 years), lower-secondary education (3-4 years), upper-secondary education (2-3 years), and higher education lasting for an average of 3-5 years (Oketch, 2007).

In Finland, the Finnish National Board of Education (2010) reported that VET as well as vocational competence play major roles in reinforcing economic competitiveness and wealth (Tessaring & Wannan, 2010). Multipurpose skills are the features of the world markets' future in which broadened competencies that are demanded. The present author concurs with their argument that VET development depends on quantitative and qualitative data anticipation in which quantitative information refers to long-term labor market demands attached to educational needs while qualitative information refers to the skillsets required at the national level respectively.

In the Russian Federation, the TVET strategy is to create a competence-based TVET system that is flexible and adaptive to change as well as taught by qualified and motivated trainers, to foster continuing vocational education and training as well as lifelong learning, and also to enhance the quality of TVET and to establish an independent quality assurance system for it. To do that, all teachers, including TVET teachers are obliged to attend at least one in-service training program every 5 years to ensure the relevance of TVET training as their professional development so as to provide the qualified labor force necessary for meeting the needs of the rapid developing economy (UNESCO, 2012).

In Asian countries like Singapore, which has been involved for half a century in professional and technical education development, its continuing education and training highlight technical and vocational education as well as a new national initiative called SkillsFuture (Ramos & Gopinathan, 2016). Singapore is renowned for international education as well as training and has successfully developed a high-performing education system that addresses skill set demands along every phase during its development. According to Ramos and Gopinathan (2016), the Singapore government in early 2015 launched the SkillsFuture initiative, a national movement to stress the demand of skills and ensure lifelong high-quality learning and employment that will help spearhead a creative economy. Kumar (2004, p. 559) pointed out that Singapore's approach to lifelong learning is pragmatic and rational, with an aim to enhance its competitiveness in the global economy. Continuing education and training (CET) projects in Singapore offer educational programs for working adults at the post-secondary level and part-time or short skill upgrade courses in occupational subject areas to enhance their employability. This approach is quite similar to a formal program in the STSC and training academies in chambers as well as unions in Hong Kong. Apart from Singapore, TVET in the Philippines is regulated by the Technical Education and Skills Development Authority (TESDA), with the aim of encouraging the full engagement and mobilization of the workforce, industry, government units, and technical vocational institutions in skill set development (Ramos & Gopinathan, 2016). Valles (2012) also claimed that TESDA has been working with local government units, NGOs, the private sector, vocational institutes, universities, and colleges to offer specialized technical and vocational training in the Philippines.

Of note, students and workers in Singapore have more advantages and opportunities to become engaged in activities for lifelong learning compared with the Philippines, which still has a long way to develop.

In the HKSAR, there is a more than 80-year history of VET. The first postsecondary technical institution in Hong Kong (Waters, 2000), named The Government Trade School was established in 1937 in Wanchai with the aim of encouraging uneducated and unemployed youngsters who had been wasting their time on the streets. It was renamed the Hong Kong Technical College after World War II in 1947 and then upgraded to Hong Kong Polytechnic in 1972 (Waters, 2002). Apart from that, the Vocational Training Council (VTC) is also one of the key stakeholders to provide TVET for both pre-employment and in-service sectors. It was founded in 1982 with a mission to develop and operate VET in HKSAR. In general, there are around 250,000 students enrolled in full-time VET pre-employment programs and on-the-job/in-service training courses for working adults offered by 13 institutions under the umbrella of the VTC. Its mission is to provide valuable choices for school leavers and working adults to acquire values, professional knowledge and skills for lifelong learning as well as enhanced employability which will support industries and manpower development. A report of the Task Force on Promotion of Vocational Education (2014) stated that VET refers to vocationally oriented programs that equipped individuals with education and training of practical skills specific at the upper secondary level for certain industries.

In Switzerland, VET and professional education and training (PET) are used. Whilst VET refers to basic vocational education pegged at the upper secondary level, PET refers to vocational education at a tertiary level, which covers programs with qualifications up to the degree level (HKSAR, 2020). The task force in the HKSAR recommended that the government rebrand VET to VPET, covering degree-level programs in Hong Kong. The VTC accepted the advice and the overall strategic plan is heading towards vocational and professional education and training (VPET) as well as lifelong learning in the modern society (VTC, 2016). Lee and Liu (2016) stated that VPET enhances learners' acquisition of professional knowledge, application of practical skills and development of positive workplace attitudes to support the long-term development of a country or a city. One important milestone in VTC is establishing STEM education centers to serve as a platform for cross-disciplinary projects in public and primary/secondary schools through seminars, workshops and international events. Within the VTC STEM education center there are four main zones (virtual experience zone, mathematics and science corner, engineering and technology zone and STEM activity workshop), with four strategies to promote STEM education effectively. The first is to strengthen STEM student support by enhancing their mathematics and science learning, the second is to raise students' study interest in STEM related subjects, the third is to enhance STEM teacher professional development, and the last one is to attract young students to STEM careers which may help to create a stable manpower pool to support SD in industries. Obviously, this shows a direct relationship between STEM education and training and TVET. The principal investigator can also see students exchanging views and sharing the learning experiences and applying STEM principles to solve real-life problems. Last but not least, information and communication technology (ICT) applications are mostly found in TVET; they include virtual training content using simulators and virtual or augmented reality (VR/AR) software, podcasts, massive open online courses (MOOCs), blogs, YouTube, videos, tablets, smart phones, etc. (UNESCO, n.d.). This renders some ideas for the principal investigator to plan and set up the STEM activities in this research study.

Besides the VTC, the STSC under HKFTU is also a key provider of TVET for in-service practitioners from most industry career stages. The STSC was established in 1980 to help citizens obtain professional qualifications by offering diversified programs that embrace occupational, leisure and other short courses in Hong Kong. The STSC provides around 5,000 programs every season in various fields, such as cookery, fashion, beauty and medical care, which assist employees in Hong Kong to enhance their skills, competence, and employability in the challenging job market (Hkftustsc, n.d.). Furthermore, other organizations, trade chambers and worker unions, like the Clothing Industry Training

Authority (CITA), Hong Kong Wearing Apparel Industry Employees General Union (HKWAIU) and some private associations, are also offering vocational training courses to practitioners from industry along their lifelong learning pathway.

2.3 The Significance of STEM Education and Training

In general, TVET comprises STEM elements with close relationship to STEM education and training. STEM does not have a simple definition; from the literature, it can be viewed as an inquiry approach in education, which requires teachers to "encourage and model the skills of scientific inquiry, as well as curiosity, openness to new ideas, and skepticism that characterize science" (National Research Council 1996, p.37).

Song, Jho, and Hong (2016) mentioned that many countries stipulate the significance of STEM and its implementation in education. For instance, in the United States there are many efforts to support STEM education (The STEM Education Coalition, n.d.) and NGSS (Next Generation Science Standards), which stress science and engineering knowledge as well as practices (National Research Council, 2012). The UK has a nationwide network for STEM (i.e., STEMNET), while science coursework in Singapore stresses inventive thinking and activities (Ministry of Education in Singapore, 2012, 2014). STEAM (STEM + Art) is an even bigger buzzword than STEM. STEAM activities encompass artistic or creative elements, in additional to one (or more) of the traditional STEM pillar subjects (Gosciencekids, 2017). Importantly, STEAM projects tend to make STEM subjects more interesting and artistically inclined. The Korean government has driven the integration of school science with other disciplines through STEAM education (Ministry of Education Science and Technology, 2011a). In Korea, several curriculum revisions have been implemented to lay stress on integration. STEAM education, by introducing arts into STEM education, has been adopted in the education system and a number of related programs have been developed by the Minister of Education, Science and Technology (MEST) and the Korean Foundation for the advancement of science and creativity (KOFAC) since 2011 (KOFAC, 2011; MEST, 2012; Oh, 2015; Sim, Lee, & Kim, 2015). However, teachers seem to lack a grasp of STEAM education and integrated curriculum (Han & Lee, 2012; Lee, 2013; Lim, 2012; Shin et al., 2012) and their competence needs to be enhanced (Oh, 2015).

From an educational perspective, the introduction to STEM can be a variety of activities, but generally speaking, it usually includes the replacement of traditional lecture-based teaching strategies with more inquiry and project-based learning approaches (Breiner, 2012). STEM education can also link scientific inquiry, by formulating questions answered through investigation to inform students before they engage in the engineering design process for problem solving (Kennedy et al., 2014).

In the past, STEM education was focused on improving science and mathematics as isolated disciplines (Breiner et al., 2012; Sanders, 2009; Wang et al., 2011) and STEM education was mostly related to science and mathematics for middle and high schools, it seldom mentioned technology and engineering. Also, in many schools, science and mathematics were taught separately with little or no attention to technology and engineering (Hoachlander, Gary, Yanofsky & Dave, 2011). In fact, over 100 years ago, Moore (1903) implied that students need to see the connections between "different subjects"; thus teachers at all levels need to be intimately familiar with the interrelationships among STEM disciplines. Gallagher (1971) even argued that, for future citizens in a democracy, understanding the interrelations of science, technology and society may be as important as understanding the concepts and processes of science. Moore et al. (2014) thus defined integrated STEM education as an effort "to combine some or all of the four disciplines of science, technology, engineering and mathematics into one class, unit, or lesson which is based on connections between the subjects and real-world problems" to enhance student learning (p. 38). The STEM Task Force Report (2014) adopted the view that STEM education is far more than a "convenient integration" of its four disciplines; rather it embraces "real-world, problem-based learning," which links the disciplines through a cohesive and active teaching and learning approach (p. 9). And the report argued that the disciplines cannot and should not be taught in isolation, just as they do not exist in isolation in the real world or the workforce (p. 9). The present author concurs with a general consent that the four disciplines in STEM are highly interrelated, with each influencing the others in our daily life. In fact, what separates STEM from traditional science and math education is the blended learning environment, showing students how the scientific method can be applied to their daily life (Hom, 2014). The STEM curriculum integrates science, technology, engineering and mathematics by an interdisciplinary and applied approach into a cohesive learning paradigm based on real-world applications (Hom, 2014). Under the theory of constructivism, De Groof et al., (2012) mentioned that the framework for teaching integrated STEM consists of the integration of STEM content, problem-based learning, inquiry-based learning, design-based learning and cooperative learning. Also, STEM activities provide a wonderful opportunity for integrated learning, hands-on discovery, and adaptations to ensure that lessons can reach students of all levels of learning ability (Steampoweredfamily, 2020). And a good STEM activity should encompass at least two of these four elements (science, technology, engineering and mathematics); this encourages exploring, discovering, learning and creating during the entire process.

In what follows are few examples of STEM activities relating to TVET. During the hands-on activity in creating electronic textile art, a student's background understanding of electricity and circuit-building is reinforced as they learn and create wearable, light-up e-textile pins. The student makes use of fabric, LED lights, stainless steel conductive threads and small battery packs to design and fabricate their own light-up pins, which involves putting together the circuit as well as the sewn-in LED lights. Students are briefed before the

STEM activity, and given the materials list and worksheets; they then explore and work on the LED light-up pins with coaching and support as well as a safety alert on procedures from teachers in the workshop. Upon product completion, students insert the coin battery into the battery holder and show off their wearable, light-up art pin successfully (TechEngineering, 2021). This is an interesting hands-on STEM activity relating electronics, circuit design, and engineering as well as LED technology in the field of fashion and textiles, which can inspire the principal investigator to design and set up similar STEM activities. For example, a thermal conductive garment product might use metallic threads or graphene driven by a dry portable cell in latter STEM activity for this research study.

Another example is about digital learning in TVET, in which a virtual learning module can adopt an animated 3D rendering of the technical item under study. The 3D model of the virtual design is realistic in all detail and constructed layer by layer and “assembled” in an animated format in which the model can be rotated to view all sides during presentation (Labtech, 2011). Again, this model of STEM activity can inspire the principal investigator to think of and design an activity of virtual garment design, fitting, and 3D catwalk presentation for STEM activity in this research study. In between, students can apply their knowledge gained from VR software to construct garment layers such as a liner, a middle layer of filling, and a fabric shell via VR software and finally dress it onto the avatar for a 3D virtual catwalk presentation.

Finally, an example about developing skills for maintenance and repair in engineering discipline. Learners need to be trained on how to fix an electrical failure at a power plant, as the company cannot introduce a real failure (i.e., shutdown) into the system. To train the learners how to respond, learners can be trained and started the activity in a virtual plant by VR software. They have to learn how to assess and fix a fault without actually disrupting the service as well as observing safety concerns (Veative, 2019). Although this is not directly related to the fashion and textile discipline, the principal investigator can make reference to the safety issue instead of bringing students to an outdoor environment under black rain and storm signals. The principal investigator can adopt VR to simulate an adverse weather occasion for students to test and experience how water-repellent garment products work under a safe virtual scenario.

The literature review shows that STEM education teaching is enhanced when the teacher has sufficient content knowledge and pedagogical content knowledge (Nadelson et al., 2012). Instead of teaching content and skills and hoping students will see the connections to the real-life application, an integrated approach aims to locate connections between STEM subjects and provide a relevant context for learning the content. Concern for improving STEM education in many countries has grown as demand for STEM skills to meet economic challenges have become increasingly acute (English 2016; Marginson, Tytler, Freeman, & Robert, 2013; NAE and NRC, 2014). STEM educators and industrialists in European countries have identified a widening STEM skills gap among the workforce, thus improving STEM education is driven increasingly by economic concerns in these countries as well as developing and emerging countries (Kennedy & Odell, 2014). A true STEM education should increase the student's understanding on how things work and improve their use of technologies. Engineering is directly involved in problem solving and innovation, therefore student should learn about engineering and develop skills and abilities associated with the design process (Bybee, 2010). Millar, J.D. has pointed out that it is necessary to understand the nature of scientific knowledge in order to develop students' sensitivity to the social issues of science. Meanwhile, Driver provided a vital contribution to the understanding the nature of science: "make clear reflection on the nature of scientific knowledge, observation and experiment, the nature of theory, the relationship between evidence and theory (Osborne, Ratcliffe, Collins, Duschl & Millar, 2001). However, in the current technologically driven world, the “T” that stands for technology is basically the sum of techniques, skills, methods, and processes adopted in the production of goods or services. Basically, technology is not simply a tool, but an area of interdisciplinary study that should also play a part in preparing students for the future economy. Many educators see the study of technology as an opportunity to teach students how knowledge, tools, and skills in math as well as science can be used to solve practical problems and extend human capabilities (Cavanagh & Trotter, 2008). Technology is important in a society, and technological literacy is something that can and needs to be developed in various parts of the curriculum to focus on teaching and learning of handicraft skills actively (Vries, 2011). The term “technology” in the broad sense means human activity that transforms the natural environment to make it fit better to human needs (Vries, 2005). Higgins and Spitulnik (2008) emphasized that technology is especially important in science education because of its dynamic representation of complicated situation with regard to STEM education. Barak (2014) also suggested that ICTs are particularly helpful in “representing scientific knowledge, describing abstract phenomena as well as predicting scientific processes”. Within the acronym STEM, Vries wrote, “Engineering can differ from technology in that engineering only comprises the profession of developing and producing technology, while the broader concept of technology also relates to the user’s dimension. Technologists are more than engineers, deal with human needs as well as economic, social, cultural or environmental aspects of problem solving and new product development” (in Barak, 2012, p.38). Barak (2012) suggested that both engineering and technology are so closely related that they should be taught in unison within technology education and suggested teaching them as one subject namely engineering technology education. Moreover, STEM educators should provide students with opportunities to think through technology as a vehicle for change, with both positive and negative impacts on culture, society, politics, economics, and the environment. Last but not least, the incorporation of STEM practices should encompass the mathematical analysis necessary for evaluating design solutions, providing the relevant rationale for students to learn mathematics and realize the connections between what is learned in school with what is needed in STEM career skills (Burghardt & Hacker, 2004). The present author concurs that during the pilot study of training on the “let-out” process for fur strips, students can make use of the mathematical calculation of desirable stripe angles and re-align strips to form the most aesthetically pleasing look for the fur garment design.

STEM education has aimed to provide all students with critical thinking skills for problem-solving in an authentic workforce environment. Educators, policy developers, and business and industry organizations are highlighting the urgency for improving STEM skills to meet current and future social as well as economic challenges (Caprile et al., 2015; Honey et al., 2014; Marginson et al., 2013; Prinsley and Baranyai, 2015; The Royal Society Science Policy Centre, 2014). Hence, developing competencies in the STEM disciplines is regarded as an urgent goal of many education systems, fueled in part by perceived or actual shortages in the current and future STEM workforce (Caprile et al., 2015; Charette, 2013; Hopkins et al., 2014; The Royal Society Science Policy Centre, 2014).

Studies have reported that students who had participated in STEM education have a greater advantage if they attended STEM field subjects in college (Butz et al., 2004). STEM education has been implemented in schools and colleges to ensure the future workforce will be equipped with sufficient scientific and mathematical backgrounds to enhance skill set development across STEM disciplines (Ejiwale, 2013). In addition, in many countries discussion about STEM is advanced in terms of claims about shortages of highly skilled labor (Marginson, Tytler, Freeman & Robert, 2013, pp.12-20). The manufacturing sectors faces an alarmingly large shortage of labor with the necessary skill (Hom, 2014).

In Australia, the Australian Science and Mathematics School was established to address the declining enrollment in senior secondary mathematics and science, a shortage of qualified STEM teachers and a curriculum lacking in relevance to contemporary life. Thus, a transformation in STEM education was seen to be required, and the key professional learning strategy employed by the school to transform STEM education was the engagement of teachers and academics as professional partners in a form of partnership (Bissaker, 2014). As mentioned by Gonzalez and Kuenzi (2012), education that includes STEM activities across different grade levels–from pre-school to post-doctorate programs–could exist in both formal and informal classroom settings. Students would have to apply the mathematics and science knowledge they learned during their STEM lessons to tackle an engineering problem and use technology to find the appropriate solution. Moreover, STEM promotes applied and collaborative learning, and technology has to be integrated into curricula and teaching methodologies in classrooms to enhance the learning experience as well as provide relevant knowledge (Kennedy & Odell, 2014). Quality STEM education could sustain or increase the STEM pipeline of individuals to prepare for careers in related fields (Stohlmann et al., 2012). And improving STEM education may also increase the literacy of all people across the population in technological as well as scientific areas (NAE & NRC, 2009; NRC, 2011). Kennedy and Odell (2014) also argued that high-quality STEM education reflects rigorous mathematics and scientific content and instruction, as well as up-to-date integrated technology and engineering. It promotes engineering design and problem-solving, encourages an inquisitive spirit in project-based learning (PBL), develops minds-on, hands-on action with a collaborative approach to students' learning; addresses student's outcomes; and offers students interdisciplinary and multi-perspective viewpoints. The present author believes that PBL can not only enrich the learning experience but also strengthen the communication skill among students.

However, with regard to STEM, it was uncovered from the literature about students' attitudes towards science and technology that Francis and Greer's (1999) found that in general men "record a more positive attitude towards science" than women do. Women are much less interested in laboratory-based sciences, physical science and engineering subjects because they cannot make affective links between those subjects and what they care about (Miller et al., 2006). While from students' perception of science, Jones et al. (2000) indicated that more women than men significantly reported that science was difficult to understand, which made them less oriented to science-related subjects.

With regard to STEM education, Gomez and Albrecht (2014) argued that the pedagogy in STEM education and training has been designed to provide trainees with a meaningful and comprehensive as well as a real-world context learning and practical experience. They advocated introducing students to available STEM careers by connecting them to actual STEM professionals who can act as role models and career mentors, showing students how their schoolwork applies to the world and their future job opportunities. Moreover, educators should know how to set up programs that engage students in a real-world learning experience that is more rewarding and relevant to their lives and can lead them to develop interest in STEM careers (Cole, 2011).

Finally, Kennedy and Odell (2014) indicated that STEM programs of high quality should (a) embrace integration of technology and engineering into science and math curriculum at a minimum; (b) promote scientific inquiry and engineering design, including rigorous mathematics and science instruction; (c) providing collaborative approaches to learning, connecting students and educators with STEM fields and professionals; (d) provide global and multi-perspective viewpoints; (e) incorporate strategies such as project-based learning, rendering formal and informal learning experiences; and (f) include appropriate technologies to enhance learning.

The requirement for STEM jobs has continued to surge in our increasingly global economy. STEM education and training in specific areas is designed to equip young people with professional knowledge and skill competence for problem solving and to face the challenges of rapid scientific, economic and technological developments (Curriculum Development Council, 2015).

In recent years, Pasi Sahlberg has used the term "global education reform movement" or GERM, to describe the emergence of a new global orthodoxy in education policy (Kay & Howard, 2019). Sahlberg has identified the principal features of 'GERM' as increased standardization, a narrowing of the curriculum to focus on core subjects/knowledge, the growth of high-stakes accountability and the use of corporate management practices (Kay & Howard, 2019).

Educational changes are taking place around the world in response to the trend of globalization and the need to raise one's competitiveness in the world (Lam, 2006). And the new global economy is more fluid and flexible, requiring workers to have the capacity to learn quickly as well as to work in reliable and creative ways. Economic restructuring calls for corresponding changes in education policy to nurture a new generation of students/workers who are capable of meeting the challenges (Lam, 2006).

In Asia, debate has also centered on questioning the ability of the education system to meet the market demands for a knowledge-based workforce (Levin, 1994; Mok & Chan, 2002). "The world has changed, so must the education system!" This statement started the chapter titled "Background to the Education Reform" in *Learning for life, Learning Through life: Reform Proposals for the Education System in Hong Kong* (Education Commission, September 2000). This reform proposal was endorsed by Tung Chee Hwa, the previous chief executive of the HKSAR, in October 2000 (Lam, 2006). To cope with this direction, the Hong Kong senior secondary (SS) curriculum has been reformed to promote students' learning capabilities. The restructuring of the academic structure and curriculum of the SS education in 2009 has witness the ongoing drive of Hong Kong Education Reform in 2000 for a “more flexible and diversified” curriculum (Education and Manpower Bureau, 2005, p. 9). Lam (2006) pointed out that under the new secondary school (NSS) “3+3+4” academic structure, all students will enjoy 6 years of secondary education (including 3 years of junior secondary education, 3 years of senior secondary education and 4 years of university education). Furthermore, to develop student’s ability to make connections across knowledge and concepts from different disciplines and to examine issues from multiple perspectives, new interdisciplinary subjects like Liberal Studies and Integrated Science have been introduced into the NSS curriculum (Cheng, Lam, Yeung, Lee & Lam, 2010). The curriculum comprises three components of core subjects, elective subjects and other learning experience (OLE) in which students should not be narrowly streamed in the arts, science, commercial or technical studies as before; rather, they should be engaged in a range of subjects that will develop their personal interests and abilities as well as open up a number of pathways for their further studies and careers (Chan, 2010). Furthermore, under the NSS curriculum, teachers are required to plan, organize, and implement relevant OLE activities to capture students’ learning experience (Chan, 2010). Overall, this large-scale education and curriculum reform was performed to enhance the quality of education as well as lead students toward a lifelong learning roadmap so that Hong Kong could really sustain its development toward a knowledge- and competence-based society (Yeung, Lee & Lam, 2012). Apart from OLE, Chan (2010) also described an applied learning (ApL) component, which is an integral part of the SS curriculum with the goal to nurture students’ basic skills, critical thinking capabilities, interpersonal relationships, values, attitudes and career-related abilities. This approach is required to prepare students for academic articulation, work, and a future lifelong learning platform.

Lifelong learning is a global model for education reform in the 21st century; it stresses the role of post-secondary education and training. In particular, job-related career orientation in adult training and learning in most Asian societies emphasizes skills and competence (Han, 2007). ApL comprises six areas (which mostly embrace STEM elements): creative studies; business; communication and media; law and management; customer services; and applied science, engineering, and production. Secondary students at the fifth and sixth levels may opt to take ApL courses as elective subjects according to their aspirations, interests, and abilities. All of these areas can pave the way for students who have an early interest in a vocational route instead of a traditional route for further academic advancement.

The educational reform is creating new roles for teachers in schools that go beyond classroom routines and practices (Kfour, 2000). Teachers should be able to share the school leadership and play a critical role in fostering student learning, curricula, assessment, and instruction, as well as their professional growth in the teacher leadership role (Crowther *et al.,* 2002; Goleman, 2002; Gronn, 2000; Harris, 2002; Jackson, 2002; Spillane *et al.,* 2001).

By and large, the present author holds the view that STEM education can practically replace the traditional teaching methods with more focus on student-centered learning approaches, through which they can acquire new knowledge and solve problems through inquiry and project-based approaches critically as well as collaboratively, which should be in line with their daily life.

2.4 Technology-Enhanced Learning

Technology-enhanced learning (TEL) is one of the pedagogical methods adopted in contemporary education, especially under STEM education and training. To align with the international trend on adopting information and communication in education, the government of HKSAR has recently broadly promoted the implementation of e-learning in schools through the application of mobile devices such as smartphones, tablets, and electronic textbooks to support classroom teaching and students' self-regulated learning (Lam, Yeung & Yeung, 2015). The Education Bureau of HKSAR (Education Bureau, 2009) has advocated the development of e-learning resources for all school subjects in HKSAR and those resources should effectively cater to the learning diversity of individual student. In fact, students integrate their science learning through technology-enhanced learning, and particular computer-based laboratory, where they can display the data in graphical or tabular form and all routine tasks are computerized, thereby saving more time for other activities like creating and answering their own questions (Ng & Yeung, 2000; Steinberg, 2003; Taylor, 1997; Tho & Hussain, 2011). Furthermore, innovative devices embedded in the design of effective pedagogies are largely adopted for different types of learning activities, namely hands-on STEM activities, field trips, scientific investigations and project works (Yeung, Wang, Lee, Chan & Cheang, 2019).

In recent decades, technology-enhanced learning has been evolving into smart technology with advance in devices such as, mobile phones, tablets, and personal digital assistants (PDAs), so on and so forth. In fact, the smartphone is not only a mobile device used for communication but is also integrated with a PDA and other technological capabilities such as magnetic and light sensors, cameras and Global Positioning System (GPS) units (Tho & Yeung, 2014a). Castro-Palacio (2013) mentioned that by using mobile phone acceleration sensor to collect data in physics experiments, the results agreed well with measurements obtained by other methods, and that this is likely to find increased use in instructional laboratories. Smartphone technology has the potential to serve as an excellent tool for students to conduct scientific investigation as well as learn scientific concepts (Tho & Yeung, 2014a). The advantages of mobile learning are well-known not only because this type of learning enables self-regulated and collaborative learning activities between learners, anytime and anywhere (Attewell & Savill-Smith, 2004), but also because it facilitates paradigm shifts in education, like a spatial shift from campus-based to home-based learning mode, and a shift in the teacher's role from knowledge-provider to facilitator in learning (Ally, Grimus, & Ebner, 2014; Alrasheedi, Capretz, & Rada, 2015; Desai, Hart, & Richards, 2008). However, implementation of mobile learning is facing many challenges and barriers, such as fragmentation of learning time, the high cost of mobile devices and connectivity service, and possible abuse of the devices for personal calls and other non-educational purposes. This requires further study and analysis prior to full implementation in teaching and learning (Denk, Weber, & Belfin, 2007). The literature review showed that with regard to the pilot implementation and evaluation of mobile learning in Hong Kong teacher education, students have shown a greater level of engagement and collaboration in their learning process, as well as finding joy and happiness in the successful completion of their tasks during lesson. The results could be viewed as favorable evidence for the widespread incorporation of innovative mobile learning activities in educational programs (Lam, Yeung & Yeung, 2016).

Recently, open-source software and freeware-based experimental development have become important features of laboratory process (Ajith Kumar et al. 2009; Tho & Hussain 2011; Tho & Yeung 2014b; Wheeler 2011). In addition, teachers can formulate an innovative, low-cost, and open-source approach for rapid development of online experiments that can be easily accessed by students with a light-weight web browser on any device and operating system without installing any additional/specific software or apps (Xu, Wang, Chan & Yeung, 2019). Actually, low-cost technology not only allows experiments to be conducted in the context of school laboratories but also gives students the possibility to learn science-related matter in real-life contexts. With the ubiquitous use of mobile and smart devices in our daily life, there is plenty of room for creating much more attractive and interesting learning and teaching activities for meeting the needs of informal science learning (Tho & Yeung, 2014a).

With reference to the literature, Frost (2010); Ross, Lakin, and McKechine (2010); and

Yeung (2002) have mentioned that various innovative instructing approaches and TEL or computer-aided practical techniques should be widely incorporated into teaching science-related subjects enriched with STEM elements. For instance, remote-controlled experimentation refers to real-time computer-based or Internet-based controlled experimentation that can allow students to manipulate or control real apparatuses or devices to complete experimental activities for scientific investigations at a distance with the application of specific hardware and software (Scanlon et al., 2002, Scanlon, Colwell, Cooper, & Di Paolo, 2004; Wu et al., 2007). Overall, this approach of remote-controlled experiment can be considered to have two educational merits in science education (Colwell & Scanlon, 2002; Scanlon et al., 2004): first it can help to increase students' participation in experimental activities, thereby solving access problems; and second, remote-controlled experiments can help to stimulate students' interest in science learning, thereby enhancing learning outcomes respectively.

Under the rapid technological advancement and the prevalent use of the Internet in education, conducting practical science tasks via a web-based laboratory or remote laboratory (RL) system has recently been adopted in cloud computing. And a RL system could enable students to conduct real-world experiments at a far distance (Scanlon et al., 2004, p. 154). This RL approach can offer a new alternative to practical learning, extending within and beyond traditional practical work, especially for prolonged observation or data collection in science experiments (Souter & MacVicar, 2012; Tho & Yeung, 2015). A remote-controlled experiment via open-source software called the LabVNC demonstrated potential in helping students learn the target topic under the approach of learning observation fruitfully (Kong, Yeung & Wu, 2009). Tho and Yeung (2014b) concluded from survey findings in a pilot study on a RL system for technology-enhanced science learning in undergraduate courses that students basically agreed with the appropriateness of using the RL system, with some comments and suggestions for continuous improvement. Students could use their computer laptops, tablets, or wireless devices to monitor and control the apparatus in the experiment and download real-time data in any location or even at home. Thus, a RL could be considered a new development in TEL that was creatively applied in STEM-rich science education (Tho & Yeung, 2016).

From this point of view, TVET could reflect an authentic scenario from industry in a distance laboratory or workshop environment for students to experience and explore. In particular, the concept of a RL or workshop provides flexible TVET and ameliorates several potential limitations that might be associated with experiences, such as safety issues, high cost, on-site space limitation and difficulty in access to industrial environments like aircraft maintenance mills and plant rooms. In general, for conducting inquiry experiments via a RL system, hands-on activities were developed to enhance students' learning of science-related topics for the Hong Kong secondary schools' science curriculum (Tho & Yeung, 2018). However, in a RL or workshop, students might not have a chance to view and physically touch and test objects, which is quite different from the conventional on-site training and learning mode (Tho & Yeung, 2016).

Furthermore, Reddy and Goodman (2002, p.13) claimed that scientists need to conduct experiments to verify theories, whereas students are required to carry out practical or experimental works to understand the underlying theories and gain knowledge. Therefore, laboratories or workshops with proper set up are vital simulated environments that allow students to learn by experience and explore science-related matters. In Mainland China, even though it is the largest manufacturing country in the world, with the largest number of university graduates in various disciplines, yet secondary school students are still often deprived of the chance to carry out science experiments in schools due to a lack of resources and facilities in rural region schools and exam-oriented schools that largely omit laboratory practices and hands-on activities (Xu, Wang, Sun, Tsang & Yeung, 2019). As mobile phones, computers, and Internet access are commonly available today in most homes in China, literature showed two research projects on new online experiments developed by two master of education students proved they could save time for experimental setup and plotting of graphs, as well as reduce the wastage of experimental materials which were reusable in the design (Xu et al., 2019).

Under the scope of TEL, another broad concept is the radio frequency identification (RFID) technology, which provides a way for students to understand the nature of science (Huang, Yeung, Kong & Gao, 2011). The application of Internet Protocol (IP) cameras and RFID has been commonly adopted in various industrial practices like surveillance, production and logistics platforms. An IP (or network) camera is an electronic device that works through the Internet to transmit video data or real-time optical images anywhere beyond a limited environment (Tho & Yeung, 2015). It could be used for monitoring and surveillance purposes as well as tracking target objects. Students could make use of a smartphone, laptop computer or tablet to control the IP camera at work remotely for real-time practical or experimental experience at any time through the Internet (Tho & Yeung, 2015). This could be a feasible solution for experiments or practical works that require longer times, and thus it allows more flexibility for the researcher. Moreover, an IP camera may remotely store and subsequently retrieve digital data, a design that is favorable for experimental observation in a laboratory or workshop, especially time-lapse experiments or when safety is a limitation. Huang et al., (2011) reported that an RFID system could provide students with multidimensional ways of interaction and co-operation in learning as well as sharing information. An RFID system consists of electronic tags, modulation, antennae, coding and storage devices. All data could be efficiently communicated among electronic tags and a backend controlling platform through the application program interface (API). The reader could receive commands through the API and write relevant information and data into the electronic tag for future execution, in contrast to the other automatic identification technologies, such as optical recognition technology, voice recognition and bar-code technology. In fact, RFID shows unique characteristics like extensive storing capacity, fast speed in reading and writing through wireless communication, object identification without the need for direct contact, and unique serial numbers with an anti-collision function, which could read multiple electronic tags fluently at the same time.

Furthermore, RFID technology has similar transmission features with other short-range wireless communication protocols such as near field communication (NFC), WiFi, Bluetooth, and Zigbee. There is close coupling (0 - 1 cm distance) and long-range coupling (0 - 10 cm) RFID that enables real-time dynamic communication and recording learning activities. Moreover, RFID may provide students with multi-dimensional and interactive cooperation (visual and auditory) from different geographic locations, not only used for real-time operating and recording, but also for tracking competition, learning processes, explorations, sharing and other learning experiences to facilitate the later on evaluation and reflection (Huang et al., 2011). Furthermore, RFID technology can be applied to problem-solving processes closely related to energy conversion, which could help students understand the nature of such conversion. This technology can also be combined with wireless sensor network technologies as well as temperature labels such as vibration sensors and chemical sensors that are broadly applicable to science education (Huang et al., 2011). In most industries, RFID has been commonly used in the automation as well as consumer products logistics in e-commerce.

In addition, inventions around multifunctional and low-cost data-logging systems (called mobile loggers with a companion specific app "SESlogger" apps for Android devices) can promote student-centered and collaborative learning with affordable cost for schools to implement authentic and hands-on STEM education and training (Yeung, Li, & Wu, 2009). Arduino is an open-source microcontroller platform which is bundled with various sensors for conducting scientific investigation and field-trip activities. It can be fully integrated with common mobile devices through the Android-compatible SESlogger for the ease of collecting, recording and sharing data among users in distant locations (Yeung, Cheang & Fok, 2015). As practiced in many places, the application of a data-logging system for hands-on experimental activities is crucial in school science learning. It can facilitate STEM education, especially in field trip activities since students can learn and modify the instrument and code small apps to control or manipulate the data logger (Yeung et al., 2009). Advantages include high sensitivity for measurement; the ability to monitor the experiment over a short to long period of time; and recording, storing, and data presentation capability in automatic sequences, which saves time for repeating experiments under different settings and parameters (Ng & Yeung, 2002). The HKSAR Education Department has added data loggers into the standard equipment list for secondary schools (Science Education KLA, 2000), and most secondary school students agree that data logging could enhance data measurement, data recording and data analysis during experiments. Finally, computer programming is also an essential skill to support all the relevant technical fields (Chiu, 2019). And, there are other low-cost technologies that can help students to understand science and physics principles through free open-source software together with the Wiimote controller (a console for playing Nintendo's Wii electronic games) as a reliable sensor. With these technologies, teachers can design innovative and low-cost science-related experiments to collect the data during the lesson (Chan, Tho, & Yeung, 2015).

Over the last decade, many institutes have continuously devoted resources and efforts to select, acquire, modify and employ various VR and 3D visualization technologies embracing low-end to medium-quality hardware and software for courseware development and viewing.

These can be used for effective teaching and learning of science topics through the Internet (Yeung, 2011). From the literature review, Yeung (2002) identified many topics that commonly cause obstacles, difficulties, or misconceptions for students but that can be taught and learned more effectively with the aid of 3D visualization and/or VR. Such innovative learning media like 3D visualization and VR technologies can help to provide a wide variety of self-learning materials for effective learning and teaching in 3D medical images, molecular modelling, visualization of complex scientific data and entertainment (Yeung, 2004). With the rapid advancement in 3D and computer technologies, VR has become much more user-friendly in affordable process within a few years; therefore, it will likely be incorporated as a part of IT in education and advocated by local governments in their educational reform agenda (Yeung, 2004). Yeung (2002) has uncovered that students can be taught and learned more effectively in science subjects with the aid of 3D visualization and/or virtual reality. For examples, Wang and Yeung (2001) identified specific courseware developed for science training; these include basic optics using 3D, VR crystal lattices, and 3D molecules of chemical and biological substances. According to Youngblut (1998), these technologies are capable of enhancing student-centered (or self-organized) learning because of unique features and educational values as embedded in adopting 3D and VR media for learning. Furthermore, these learning resources can help students develop their ability to visualize, understand, and construct the details of complex scientific data as well as models, compared to 2D monoscopic images.

Cheng and Yeung (2009) highlighted the inter-relationship of science, technology and society because mankind is living in an era dominated by science and technology, and sustainability has become a concerning issue in education and society. Given the growing global concern on climate change and global warming issues, it has become necessary to address the strengths and limitations of science and technology in college education and society. Therefore, it is crucial for all youth to incorporate a scientific attitude in their everyday lives. Problems should be tackled, and information should be evaluated with a scientific mind-set and manner with an intention to arrive at a satisfactory solution (Gauld & Hukins, 1980).

The recent STEM education literature provides a rationale to teach STEM concepts in a context that deploys project-, problem-, and design-based approaches (Carlson & Sullivan, 1999; Frykholm & Glasson, 2005; Hmelo-Silver, 2004; Kolodner, 2006; Kolodner et al., 2003; Krajcik et al., 1998). With regard to pedagogy, to align with the scientific and analytical attitudes of mind-set, problem-based (PbBL) and project-based (PBL) learning approaches can be introduced to facilitate desirable outcomes. At a more general educational level, a PbBL approach has been found to enhance specific learning skills such as knowledge construction and reasoning (Albanese & Mitchell, 1993). This builds positive study attitudes (Kaufan & Mann, 1996) and the transfer and integration of concepts to new problems (Norman & Schmidt, 2000). Tan (2003) defined the PbBL concept as a progressive active learning and learner-centered approach where unstructured problems are used as the starting point and anchor for the learning process. In brief, the PbBL pedagogical approach enables students to learn while engaging actively with meaningful problems. Students are given opportunities to solve problems in a collaborative setting, create mental models for learning, and form self-directed learning habits through practice and reflection (Hmelo-Silver, 2004; Norman & Schmidt, 1992; Schmidt & Moust, 2000). Moreover, Strobel and van Barneveld (2009) analyzed a number of meta-analyses on the effectiveness of the PbBL approach and found that it is more effective than traditional approaches when the measurement of learning outcomes is focused on long-term knowledge retention, performance or skill-based assessment and mixed knowledge and skills.

Regarding the project-based learning (PBL), it focuses on “more authentic experiences in the real-world beyond school walls" according to John Larmer who was the editor in chief of the Buck Institute for Education's PBL Works. PBL presents an original approach to STEM centric PBL. It can also be defined as an "ill-defined task with a well-defined outcome". This emphasizes a backward design that is initiated by well-defined outcomes, tied to local, state, or national standards that provide teachers with a framework for guiding students' design, solving, or completion of ill-defined tasks (Capraro & Morgan, 2013). Because traditional instruction in classrooms might be a bit boring, Railsback (2002) identified a number of important benefits of project-based learning: it is active instead of passive; it is interesting and relevant to the student; it allows for autonomy and self-directed learning; it increases communication skills; and it enhances motivation to learn.

Besides linking real-world issues to classrooms, PBL also requires significant teacher-student interaction at a group level. Steinemann (2003) mentioned that PBL has been widely identified as an effective approach for education for sustainable development because it focuses on complex interdisciplinary problems and provides students with the opportunity to gain experience through addressing those problems that they might encounter in their future careers. Krajcik and Shin (2014) noted that PBL is a form of situated learning that is based on constructivism theory, which suggests that students gain a deeper understanding of learning material when they actively construct their understanding by working with and adopting ideas from a real-world context. PBL derives its theoretical underpinnings from constructivist epistemological belief that emphasizes rendering a rich context for knowledge construction (Driscoll, 1994). With the interaction and learning support from peers and scaffolding provided by instructors, it is agreed to have certain learning benefits that can provide new insights. Ultimately, the goal of PBL is to impart the 21 st century skills such as analysis and informed decision making by developing intrinsic motivation among students that boosts their engagement and understanding (Bonderud, 2019). Meyrick (2011) mentioned that 21st century skills embrace but are not limited to collaboration, critical thinking and inter-personal communication, among many others. These skills include inquiry processes, problem-solving, critical thinking, creativity and innovation as well as having a strong focus on disciplinary knowledge (English & Gainsburg, 2016; Marginson et al., 2013; Partnership for 21st Century Skills, 2011). Also, the learning and thinking skills comprise creative and innovative skills, communication skills, problem-solving skills, collaboration skills, and informative and media literacy skills. Finally, essential life skills include leadership, adaptability, self-direction, and social responsibility (Fadel, 2008).

From the literature information, Boaler (2002) compared student mathematics achievement in two similar British secondary schools, one using traditional instruction and the other adapting project-based instruction. After 3 years, students in the project-based learning school significantly outperformed the traditional school in students' mathematics skills as well as conceptual and applied knowledge.

To employ PBL effectively, teachers must fully understand the concepts embedded in their projects and be able to model thinking as well as problem-solving strategies effectively (Blumenfeld et al., 1991). This means adopting real-life problems to motivate students, challenging them to think critically about the content, and enabling them to work collaboratively to yield the greatest benefits (David, 2008).

During the review in literature, Liu and Hsiao (2002) conducted a research study on adopting PBL with middle school students and found that it increased their "learning of design knowledge, their cognitive strategy used, and their motivation towards learning" (p.311). The study looked at engaging students as multimedia designers and investigated the learning of design knowledge, management of time and resources in group work, cognitive strategy used as well as their motivation toward learning. In the design of the study, the participants were all students from an elective class (*N*=16) of a middle school in the southwestern part of US. The cohort included 5 female and 11 male students with age range from 12-14 years old. Most of them had some experiences in software such as Adobe Photoshop and HyperStudio as well as the Internet. The class was co-taught by an art teacher and a multimedia instructor. The study took place during the spring semester of 2000, and the multimedia class met everyday around 45 minutes for a total of 18 weeks. The supporting facilities were Mac and PC computers, a color scanner, a digital camera and a video camera, as well as multimedia software like Adobe Photoshop, Adobe Premiere and PowerPoint which were widely adopted in the design process and presentation. Following a briefing on the objectives and tasks, there were three study phases. In Phase I (approximately 5 weeks) was the learning of relevant software and operational skills, whereas in Phase II (approximately 8 weeks) was focusing on group work and presentation. Within the group work, students were divided into 3 teams with about 5 students in each team, and each team had organized their role play and responsibilities as project manager, artist, researcher, programmer and audio/video specialist. Methods employed were interviews, letter writing to teachers and students as well as internet searching for them to assemble all the elements such as text, graphic, video, so on and so forth into the PowerPoint presentation. The goals for Phase I and II were to receive scaffolding guidance and instruction from teachers, especially in Phase II, instructor scaffold and help students to acquire essential skills for planning, design, producing and revising. Furthermore, a field trip to a local multimedia production company was arranged for the teams respectively. Finally, in Phase III (approximately 3 weeks) was to apply what had been learned in previous phases for a new scenario of creating a website template by their own decision.

This small scale of class (N=16) and small team (5 students per team) working on the multimedia basis can be taken as reference for the treatment class formation in this research study since they all shared similar technological basis like using computer, digital device, and design software for drawing and presentation such as Adobe Photoshop, etc. After the qualitative, quantitative analysis and triangulation, those results and findings indicated that middle school students gained noticeably their design knowledge and skillsets which enabled them to be aware of different steps and strategies involved in creating a multimedia program and to be motivated along with the learning process. However, it mentioned that constraints still existed in the facilities and locations of laboratories. For instance, the media laboratories were far away, students needed to waste time travelling to and fro to work on those software. Moreover, it also suggested to take more time on preparation, learning stage, implementation stage and so on rather than just one semester which might lead to a better overall outcome. Limitation on such a small class might affect the validity as well as reliability on the study. In light of that, it allows the principal investigator to think if the size of the treatment class is around 16 students, it would be better to arrange several treatment classes in consideration on the adequate number of participants during research study for more valid and reliable results. Another limitation was the simulated environment, ideally, there should be one dedicated well-equipped computer room for multimedia projects instead of moving from one laboratory to another. This is also an important consideration for the principal investigator to consider for later treatment classes design and setting. Finally, students seemed to prefer more time for practical works (learning by doing) instead of instruction from teacher which was definitely an encouraging approach in PBL to enhance the learning experience along the learning process. The present author concurs with the general consent that PBL with sufficient time for the practical works is absolutely a win-win solution in effective learning.

Similarly, Barron et al., (1998) also showed that academic performance and motivation are greatly improved when using PbBL and PBL in their comprehensive study on students' creation on blueprints of chairs and playhouses with presentation drawings in the class. During the experimental study, there were 5 fifth-grade classes of 111 students and 5 teachers engaged from the same middle school located in a metropolitan area of Nashville, Tennessee. Students normally worked for approximately 5 weeks on the problem and project components of the lessons where instruction occurred 4 days per week in 45-minute periods. There were three measures of student learning. First, the design-a-chair task was a performance assessment that evaluated how well students could tackle a design problem. Second measure was to capture the broad range of standards-based geometry concepts that were relevant to blueprint and the project. The third measure reflected the success with which students collaboratively designed their playhouse projects. In the first measuring process, the task was to design a chair for 3-year-old children, which should be illustrated on graph paper as a blueprint and include all the necessary information like diagrams, scales, and measurements for a carpenter to produce it. Since the carpenter was living far away from the school and had difficulty in communication, as such, the blueprint need to be drawn accurately and precisely for flawless communication. The aim of the project hoped students could learn through problem- and project-based work, (e.g., understanding the needs on suitable chair size for small child and needs from carpenter who was going to realize the design practically) and able to transfer this knowledge to any new design task.

The results reflected substantial improvement, with 71% of the students moving from either no measurement or unrealistic measurements to revised realistic measurements after intervention and guidance by teachers. This suggested that students became more attentive to real-world constraints as a consequence of the instructional sequence and scaffolding guidance from teachers. In fact, this pedagogical method could be considered by the principal investigator to adopt in the treatment classes of this research study on “let-out” process in fur design, which involves a similar blueprint design prior to the fur garment production.

The second measuring process was the standard-based geometry concepts involving scale, volume, perimeter, area, and units of measurement that embedded in the blueprint and playhouse design task. The overall results were generally encouraging. Regarding the playhouse design project, students worked in 1 of 37 groups for approximately 1 week only for playhouse design, blueprints preparation, scale model development as well as presentations. Students treasured in and demonstrated their creativity in the design and presentation embracing songs, costumes, characters and soapbox speeches for 4 to 5-year old kids to play in. In summary, those three measures of learning, students showed substantial gain in ability of understanding and communication by making use of geometric concepts and eventually applied in a new design for a real scenario. Even though there were 37 small groups of total 111 students in participation which seemed fair large enough in the research pool, however there was only one week to complete all the required works which made the validity and reliability doubtful as compared to the study on engaging students as the multimedia designers which experienced a much longer duration. By the way, the longer the duration for all processes, the better and more reliable outcomes should be attained. But sometimes, researcher has to judge and trade-off when necessary in consideration between research duration and limitations from participants as well as setting in the environment. To wrap up, PbBL and PBL help students to learn with understanding, learn how to do with understanding as well as motivation along the entire learning process. In the above two studies, duration on the projects seemed to be a vital element for validity and reliability. Apart from the participant pool, a researcher should pay absolute attention to designing a hands-on project in terms of limitations and reasonable duration required to finish the tasks, aims, and objectives, striking a proper balance for credibility and reliability in the whole research study.

All-in-all, PBL has its own unique challenges, but teachers with minimal training can basically master the approach fairly quickly. It is also believed that this method can motivate students to learn more effectively than through traditional passive teaching approaches in their classrooms. By and large, inquiry-based and project-based learning are often considered capable of increasing students' interest in learning science, developing their scientific investigation and critical thinking skills, and cultivating their ability for independent and collaborative learning via digital technology. However, lesson observation in the research study from literature review revealed that teachers still lack the abilities to handle the inconsistent data collected by students when using digital technology, and teachers still need more experience to doing inquiry in order to get deeper understanding of the nature of inquiry itself, which is helpful for dealing with the complicated situations of organizing inquiry-based project learning (Yeung & Wan, 2011).

STEM education acts as a tool in an inquiry-based approach during the entire experimental study to enable students to think, question and explore. The National Research Council (NRC, 1996) highlighted that the laboratory is especially essential in the current era in which an inquiry-based approach has re-emerged. The NRC advocated for science teaching as well as learning (NRC, 1996, p. 23) in order to lead students in a close connection between science and society. Zhou, Yeung, Xiao, and Wang (2011) designed a series of experiments with the goal of helping students gain better experience through an inquiry-based approach. Students were guided to explore questions without settling for standard answers, and they pondered all possible restrictions with regard to the application in daily life; they received feedback and the results were encouraging. Overall, science and technology under the STEM system play essential roles in driving innovative thinking and analytical mindsets of students as well as sustaining society and the living environment in more constructive ways, with an emphasis on evidence-based in the near future. Again, this can also pave the way for the principal investigator to plan the STEM activities in the research study.

2.5 Sustainable Development and FTC Industry

Many global challenges, including "climate change, overpopulation, resource management, agricultural production, health, biodiversity, declining energy, water sources, and environment," need an international approach supported by further development in science and technology to adequately address these challenges (Thomas & Watters, 2015, p. 42). There is an urgency to chart a new pathway for the world to meet a target of "no net loss of nature by 2030" and limiting climate change to 1.5 degrees Celsius. Under the goals of the Paris Agreement, nations and countries are trying to confine warming to "well below 2 degrees Celsius while striving towards 1.5 degrees Celsius (Newman, 2020). Moreover, Newman (2020) also mentioned that during the G7 Summit held in Biarritz, 32 companies in the fashion and textile industry made a pledge to work towards shared and concrete goals in the areas of climate, biodiversity and oceans. Key companies like Kering are using their influence and collaborate with the fashion industry through the Fashion Pact to work on climate, biodiversity and ocean health.

Sustainability is generally refer to the capacity for the biosphere and human civilization to coexist constantly. The SD concept first emerged in the 1960s when environmentalists started debating on the impact of economic growth on the environment. The World Commission on Environment and Development in 1987 defined SD as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs". And it is vital to harmonize the three core elements: economic growth, social inclusion and environmental protection for SD (HKSAR, n.d.). Moreover, the key principle of SD is the integration of environmental, social, and economic concerns into all aspects of decision making (Dernbach, 2003; Stoddart, 2011). HKSAR (2017) highlighted that SD in Hong Kong needs to balance social, economic, environmental and resource needs, catering to both present and future generations, which coincide with the global direction, simultaneously achieving a vibrant economy, social progress and a high quality environment, locally, nationally and internationally, through the efforts of the community and government.

It was simply stipulated in the 1999 Policy Address, the SD for HKSAR means: finding ways to increase prosperity and improve the quality of life while reducing overall pollution and waste; this would meet our own needs and aspirations without doing damage to the prospects of the future generations; and it would reduce the environmental burden we put on our neighbors and help to preserve common resources. The policy address was clear enough and the most important challenge arose in educating the public as well as ensuring effective implementation on the floor.

There are 17 goals under the SD, and those that are associated with this research topic are quality education and training, industry innovation and infrastructure, climate action and life under water, good health and well-being, clean energy, and responsible consumption of resources as well as production (United Nations, 2015). Similarly, Griggs, Smith, Gaffney, and Ohman (2013) claimed the SD goals would lead to thriving lives and livelihoods, sustainable food security, sustainable water security, universal clean energy, healthy and productive ecosystems and governance for sustainable societies.

Referring to the definition of SD, it basically consists of three pillars namely, economic, socio-cultural and environmental development (AIP Conference Proceedings 1887, 020076, 2017). Actually, SD is not a fixed concept but rather is a culturally directed search for a dynamic balance in relationships among social, economic and natural systems (UNESCO-UNEVOC, 2005).

Under the global highlights on issues of sustainability, the rapid expansion of industrialization, urbanization, technological advancement, and commercial activities in recent decades on the earth has led to pollution as by-products, which affect air, land, and water. To strive for survival, mankind should make use of its best knowledge and practice to qualitatively and quantitatively sustain the living environment. Global voices have highlighted and will continue to advocate green and eco-environment issues. Most companies are now highly committed to pursuing SD (Gershoff & Frels, 2015; Luo & Du, 2015). They should possess the ability to satisfy the demands of the present without compromising the ability of the future generation to also satisfy their demands and desires (World Commission on Environmental and Development, 1987). Otherwise, the scenarios of dead lakes in the US and mercury poisoning in Japan might appear again (Hart, 1997). A sustainable world requires a sustainable economy, which underpins a green and sustainable environment. While business, commerce and industry in the past have negatively affected the environment, industries and businesses are now striving for zero impact, while all stakeholders should target a positive impact on the environment tomorrow so as to sustain and upgrade the green surviving economy as a whole (Hart, 1997).

As mentioned previously, there has been an obvious rise in demand for STEM practitioners or professionals owing to the variety of STEM occupations in the international market. In particular, because of global environmental concern on carbon and water footprints, many fashion brands have attempted to address sustainability issues (Emberley, 1998; Moisander & Personen, 2002). With regard to the fashion business, according to empirical research on luxury fashion brands by De Angelis et al. (2017), Janssen et al. (2014) and Maignan and Ferrell (2001), the renowned Stella McCartney fashion brand has built much of its success on sustainability. Contrary to fast fashion, Clark (2008) views slow fashion as "sustainable fashion solutions, based on the repositioning of strategies on design, production, consumption, use and reuse, which are emerging alongside the global fashion supply system, and are posing a potential challenge to it. The slow approach offers more sustainable and ethical ways of being fashionable that have implications for design, production, consumption, and use" (p. 428). According to the World Wildlife Fund (2016), it takes more than 20,000 liters of water to produce 1 kilogram of natural cotton material, which is equivalent to one T-shirt and a pair of jeans. Although the production of synthetic material (e.g., polyester) requires less water and no pesticides compared with cotton, it consumed three times the energy of cotton production (Cherrett et al., 2005). Therefore, cotton and polyester material manufacturing is harmful to the environment, and cotton has the greatest negative impact as a whole (Butow, 2014). Furthermore, the 2017 Pulse of the Fashion Report, put together by GFA and the Boston Consulting Group, estimated that in 2015, the global textiles and clothing industry was responsible for the consumption of 79 billion cubic meters of water, 1,715 million tons of carbon dioxide emissions and 92 million tons of waste discharged. It also estimated that by 2030, under a business-as-usual scenario, these numbers would be increased by at least 50%. Therefore, "green" principles and strategies have become essential for companies as public awareness of their environmental impacts has increased. Green clothing (also known as natural/eco-friendly clothing) provides consumers with healthier and more environmentally friendly apparel options (Cool-organic-clothing, n.d.). Designers can make decisions about which environmental hazard to focus on to design a more environmentally friendly product causes less waste, pollution, and energy consumption (Breakthrough e-Coach, n.d.). In fact, one of the largest polluters in the world is the textile industry. The production of raw materials, spinning raw materials into fibers and yarns, weaving fabrics and dyeing require enormous amounts of fresh water, chemicals, including pesticides for growing cotton. Besides attention put in the manufacturing processes, Ozek (2017) has claimed that attention should be paid both to the design and manufacture as well as business model approaches when applying sustainability. It seems true that how textile and clothing offerings should be designed and produced to better suit customer demands in a more sustainable way has always be questioned. Garment products' life cycle, from attainment of fiber to disposal (termed "cradle to grave"), threatens our planet resources and life standards as well. One can imagine that when huge amounts of used garment products are being disposed of via either landfill or incineration, human beings have to face significant environmental issues, like greenhouse gas emissions, soil degradation, and release of toxic chemicals. Therefore, to be a well-considered supply chain, designers and product developers should commit at the early beginning by adopting green standards and recycling materials, offering green support in production process as well as thorough education about the cradle to cradle rather than cradle to grave paradigm delivered to end-users as an effective and efficient SD approach. The principal investigator thinks it is important to highlight this in education for sustainable development. Furthermore, consumers exhibit large environmental footprints due to the water, chemicals and energy used in garment washing, tumble drying and ironing as well as shedding microplastics into the environment (European Parliamentary Research Service, 2019). All of those actions are deteriorating the natural environment considerably. However, trends have been changing recently, and the key players are driving changes toward eco-friendly and forward-thinking fashion production processes as well as consumption in the industries (Henninger et al., 2016). As such, the FTC industry, which consumes a lot of energy and water, has initiated many “green” manufacturing technologies such as emissions control, water-less dyeing and processing textiles using AirDye, ColorZen and DyeCoo technologies. The carbon footprint measures the overall impact that human-related activities have on the environment in terms of the amount of greenhouse gases generated and measured in units of carbon dioxide within a period. These activities mostly relate to the energy consumed, transformed and emitted directly or indirectly into the atmosphere that underlie adverse climate changes. In DyeCoo technology, carbon dioxide is used as a dyeing medium instead of water, and the dyeing lead time for textiles is half of that required by the traditional dyeing process. In addition, energy consumption and carbon dioxide emissions are also halved (Heida, 2014). The water footprint measures the amount of water required to produce each good or service that human use. It may be measured in a single process, like rice cultivation, manufacturing a pair of jeans, and fossil fuel that we use in our vehicles. For example, ColorZen technology consumes 90% less water and fewer chemicals as well as 75% less energy compared with traditional dyeing and finishing method (Heida, 2014). Finally, the AirDye technology for yarns and textiles uses approximately 86% less energy and 95% less water compared with the conventional methods (Heida, 2014). The theme in the last ITMA fair held in Milan in 2015 was sustainability, and the manufacturers were very much concerned about lower energy consumption, limitations on water usage, recovery of heat, and reduction in all kinds of wastes (Ozek, 2017). The present author believes that since he has been to the fair for visiting and took digital records back, seminar and sharing sessions have been delivered to the FTC industry as well as the instructors in Fashion and Textile Training Center thereafter.

Apart from textile and clothing manufacturing processes, according to the Pulse of Fashion Industry report, long delivery routes also account for climate-change impacts of the industry due to waste generated through packaging, hang-tags, hangers and plastic bags. Moreover, end-use customers should attempt to reduce the washing temperature, avoid tumble-drying, wash at a full load, purchase eco-friendly fibers, and donate clothes that are no longer used for second-hand clothes reuse purpose rather than dispose of them, through which burning in incinerators or depositing in landfills will release methane and dangerous chemicals into the environment, which contradicts to the Eco-concept. Henceforth, in recent years, how to determine appropriate and green suppliers as well as logistics structures along the supply chain has become a key strategic consideration in most of the enterprises (Eryuruk, 2012).

Overall, fashion companies are encouraged to provide more traceable details and transparent information about production of sustainable fashion products, which can benefit the consumers' purchasing and consumption decisions. This is also an effective way to educate consumers and improve their awareness about sustainability and practice (Ozek, 2017). The international organization for standardization (2007) defines traceability as the "ability to verify the history, location, or application of an item by means of documented recorded identification." Traceability indeed is a link that connects various information elements pertaining to a product (Agrawal et al. 2016). In the textile sector, which is a customer-driven sector, eco-labels are widely adopted to render ecological information about the products. However, this is still being criticized somehow to create confusion leading to green washing (Henninger, 2015). While the ecological aspects of a textile product can be divided into categories and phases (raw materials, manufacturing, use, and post-use), traceability acts as a tool to trace back information to the original source (Corbellini et al., 2006; Henninger, 2015). For instance, Rapanui Clothing (2016) provides full traceability information related to manufacturing, energy consumption, carbon footprint, and how end-users can reduce the carbon footprint during the use-phase of the products, thus improving the transparency along the supply chain. This action by a key player can help to ensure the SD.

In another example, most American clothing companies provide a traceability number with their jeans, which allows consumers to trace the history of the jeans back to the cotton field (Goswami, 2014). In addition, traceability works on the unique identification of products by using technologies such as RFID tags, QR codes and bar codes as well as printed labels with relevant information encoded in those labels for identification and organization of product recall whenever necessary which has been mentioned in the previous TEL section. By and large, this correlates with STEM elements that enhance the transparency and sequence of flow in the entire supply chain. Finally, one important concern is counterfeiting, which is a threat for social and economic sustainability. By using the above-mentioned technologies for product tracing and authentication, end-users can easily differentiate genuine products from counterfeit, which helps the brand of genuine products to achieve sustainability.

Europa (2013, August) mentioned developing production processes using lower amounts of water, pesticides, insecticides, hazardous chemicals, and greenhouse gas emission, which is an essential measure to select textile products by retailers. However, consumer behavior in how they care for and dispose of clothing and other textile products is of equal significance in which the present author holds the view that customer behavior is also an important consequence in greening the supply chain.

In the term "eco-concept" under environmental sustainability, the word *environmental* mostly refers to humans' interactions with their ecosystem. To be more precise, *environmental* can be viewed as a subset of the word *ecological*. Morelli (2011) defined ecological sustainability as human-related activities that meet the resource and service needs of current and future generations without compromising the health of ecosystems. In particular, a condition of resilience, balance and interconnectivity should allow societies to satisfy their needs while never exceeding the capacity of ecosystems to regenerate the services necessary to back up those needs and demands nor to diminish biodiversity. The present author believes with Joy et al. (2012), who stated that sustainability involves a lot of complicated and changing environmental dynamics that affect human livelihood and well-being in both the local and global environment. In a sustainable future, the present author holds the view that activist and sustainability professionals hope to remove trade barriers so that they may benefit everyone, contributing to the economic and social development core of sustainability while promoting good environmental practice in the whole community.

All the technologies discussed above involve STEM knowledge and skill sets, and there is a high demand for STEM professionals in practice. Although TVET training has responded to demands from industry, it has not considered the relevant social and environmental consequences; therefore, it has been criticized for failing to equip students with a green skillset (Anderson, 2009; Arenas & Londono 2013; Bedi & Germein 2016). Rather, the pedagogy should provide experimental, interactive, transformative learning as well as real-world problem-solving opportunities to help students develop a green skillset. Cedefop (2012) defined green skills as "the professional knowledge, abilities, attitudes and values required to survive in, develop and support a sustainable society with efficient resources and green skill." These skills will be needed by all sectors of commerce and industry at all levels in the workforce. Thus, it is necessary to investigate more deeply the effectiveness of STEM elements in TVET in relation to the sustainable FTC industry. In particular, it is necessary to identify those elements in STEM that could facilitate trainees' development in vocational green skills in TVET to echo the SD highlighted in the modern era. Pavlova and Chen (2019) wrote that TVET plays a significant role in supporting a green economy and tackling environmental issues via knowledge and skillset development. And TVET should encompass green technology that is economically feasible and environmentally friendly, leading to education and training to achieve SD in daily practice (AIP Conference Proceedings 1887, 020076, 2017). Indeed, a vocational green skill set plays an essential role, and it is necessary for all industries to ensure environmentally friendly practices in workplaces.

In fact, education for sustainable development has increased the focus on integrating PbBL and PBL approaches to generate more real-world learning opportunities for students to understand as well as address sustainability challenges (Brundiers & Wiek, 2013; Kricsfalusy, Reed, & George, 2018; Wiek, Xiong, Brundiers, & van der Leeuw, 2014).

There have been other opinions from FTC manufacturing as well as retailing industries about the sustainability of STEM professionals in STEM careers. They claim that the knowledge and skills from in-service practitioners are not sufficient for a variety of tasks in STEM careers. Therefore, it is noteworthy to study and examine the interrelationships among STEM, TVET, and sustainable FTC industries - to find out how STEM through TVET can promote and ensure SD in the FTC industry.

This literature review shows that it is important to reveal the role of TVET to enhance awareness of SD and SD practices at the institutional level, in preparation for a future workforce that promotes green technology (AIP Conference Proceedings 1887, 020076, 2017).

In the 21st century, fast-changing technology affects lives and the working of society. The important roles of TVET must be able to respond accordingly by offering relevant programs with STEM elements together with new ways of teaching and learning methodology to promote and support SD. Overall, recently proposed work-based, project-based, and game-based learning has been advocated for teaching by solving authentic real-world sustainable problems, as an effective path of developing competences on sustainability (Brundiers et al., 2010; Remington-Doucette, Connel, Armstrong, & Musgrove, 2013; Rowe 2007).

All in all, to minimize the impact from waste and pollution as a result of human activities, TVET should embrace or even expand green technologies by offering courses, for example, about renewable energy; clean energy which comes from natural sources such as wind, water and solar energy (Shinn, 2018); using environmentally friendly materials in production processes; and green information and communication technologies that are in line with the SD goal (AIP Conference Proceedings 1887, 020076, 2017). However, as claimed by Seidman (2007, p.58), "sustainability is about much more than our relationship with the environment; it's about the relationship with ourselves, our communities, as well as our institutions." The possible ways forward suggested by European Parliamentary Research Service (2019) embraced extending the longevity of clothes by recommending that consumers buy fewer but better quality clothes that could be used for longer, encouraging the purchase of second-hand clothes, repairing old clothes, and upcycling unwanted items. Apart from raising consumers' awareness on eco-concepts and practices, it is also important to educate them on better and more efficient washing and drying as far as water and energy footprints are concerned.

2.6 Framework and Theory Underpinning the Research Design

Having reviewed the literature on TVET, STEM education and training, SD, and FTC industry, an appropriate framework needs to be employed for the entire research study. A design framework can normally provide guidance about all facets of the study and the one from Creswell (2003) includes three elements: (a) philosophical assumptions of what constitutes knowledge claims; (b) general procedures of research named strategies of inquiry (qualitative: narratives, phenomenologies, ethnographies, ground theory, and case studies; quantitative: experimental designs, survey; mixed methods: convergent parallel, sequential, and transformative); and (c) detailed procedures on data collection, analysis, interpretation, and writing. Qualitative, quantitative, and mixed-method approaches frame each of these elements differently, so the researcher has to provide reasons for choosing one approach over another in designing a research study. Creswell (2013) mentioned that mixed-methods research is relatively new in the social and human sciences; it involves collection of both qualitative (open-ended) and quantitative (closed-ended) data in response to the research questions or hypotheses. The procedures for both qualitative and quantitative data collection need to be conducted rigorously through adequate sampling, sources of information and data analysis steps. At a general level, mixed methods draw strength from both qualitative and quantitative approaches and minimize their limitations. At a practical level, it provides a sophisticated and complex research approach with a useful strategy for gaining a more complete and intensive understanding of the problems/questions.

Regarding the theories underlying the research design for science education, constructivism as a theory of learning (Richardson, 1997) has been an influential movement in science education research over the past two decades (Matthews, 1998; Tsai, 1998). As a philosophy of education, constructivism concerns how learners construct their own knowledge actively according to interpretation in response to interaction with certain learning environments or methods (Aubusson & Watson, 2002; Bell, 1993; Jonassen, 1999; Jonassen & Rohrer-Murphy, 1999). Besides active learning, constructivism also stresses experimental learning, problem-solving, student-centered learning, and social interaction, so on and so forth. This could let students directly experience the physical world (i.e., experimental learning) as well as facilitate their active construction of meaning or science concepts (i.e., active learning) during their interaction with the environment, especially in web-based learning (Jang, 2009, p. 248). The constructive instructor provides tools such as problem-solving and inquiry-based learning activities with which students formulate and test their collaborative learning environment. This can transform students from passive learners to active participants in the learning process instead of just ingesting any knowledge directly from the instruction or textbook.

And assessment may include student works, observations, points of view, and tests in which the learning process is an important product. Taber (2011) mentioned that the goal of constructivist teaching was not only to provide "direct" instruction, or "minimal" instruction, but optimum levels of instruction, and therefore it involves shifts between periods of instructor presentation, exposition, and student engagement with a range of individual and particularly group work, some of which might seem quite open-ended. The main role of the instructor is monitoring and supporting during the teaching activities. Constructivism as a theory suggests that effective teaching needs to be both student-centered and teacher-directed (Taber, 2011). In a trial curriculum project in the US (BSCS, 1994), the curriculum package claimed to employ a constructivist approach to learning and teaching by adopting five phases known as the “5Es” (engage, explore, explain, elaborate and evaluate) (Bybee, 1997). The engage phase promotes interest and motivation, the explore phase is to investigate different phenomena, the explain and elaborate phases are for findings explanation, and the evaluate phase is to reflect on and question the ideas.

Besides constructivism, there are also other knowledge claims such as pragmatism which focuses on consequences of actions and is problem-centered, pluralistic, and real-world practice oriented; postpositivism which is concerned with determination, reductionism, empirical observation, measurement and theory verification; and advocacy/participatory which talks about political, empowerment issue-oriented, collaborative and change-oriented subjects (Creswell, 2003).

2.7 Chapter Summary

In summary, the literature review provided background information for TVET; STEM education and training and activities; green skills; education for sustainable development; TEL (mobile devices, VR, 3D visualization, web-based experiment, data-loggers, etc.); SD; FTC industry and related educational theories as well as pedagogy. It underpinned but also showed the relationships among STEM, TVET, the FTC industry, and SD, together with insightful information about sustainability, eco-concepts, an eco-friendly environment, carbon dioxide and water footprints, energy consumption and green supply chain operation. All of these are related to eco-concepts and technologies that encompass STEM knowledge and skill sets which are supposed to be acquired in TVET training. From the literature review, STEM activities can be viewed as an inquiry-based learning approach in which students can construct, understand, learn, and come up with new ideas under the scaffolding guidance of an instructor during the learning process in the activities towards an objective in the study. The academic literature forms the theoretical skeleton and model of reference for the principal investigator to plan the research design, methodology, data collection and analysis, interpretation, discussion, and forward thinking in the following chapters of the thesis respectively.

Chapter 3 Research Methodology

3.1 Conceptual Framework

From the educational conceptualization point of view, STEM is often considered as a traditional disciplinary coursework (science, technology, engineering, and mathematics) lacking an integrated approach. Thus, the most important modern conception of STEM education might be the notion of integration – meaning that STEM is the purposeful integration of various disciplines as used in solving real-world problems (Labov, Reid, & Yamamoto, 2010; Sanders, 2009). This STEM education perspective involves viewing the four separate disciplines of science, technology, engineering and mathematics as one unit, thus teaching them as one cohesive entity. Under the SD goal, TVET plays a key role in the through-line of STEM skill set and professional knowledge from secondary education to tertiary and adult education in the lifelong learning milestone. Lifelong learning emphasizes the role of post-secondary education and training; it encompasses adult learning in a job-related career with trade knowledge assessment as well as skill validation to ensure all-round competitiveness in the society (Han, 2007).

The following framework depicts STEM education and training as being carried by TVET (a lifelong learning path in pre-employment and in-service modes) as STEM-VET to enable a sustainable FTC industry under the concept of SD.

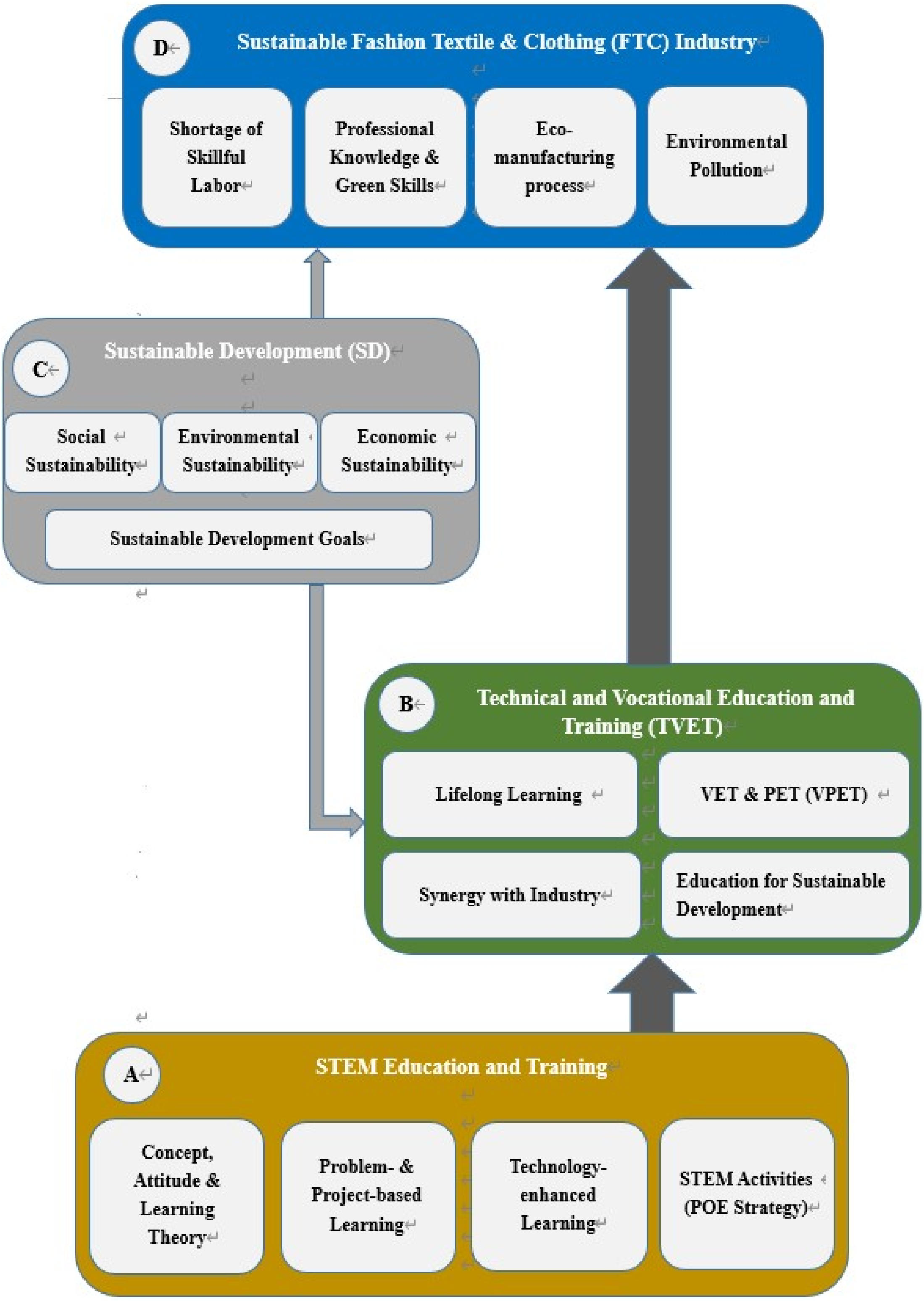


Figure 3. Conceptual Framework Showing the Interrelationships Among STEM Education and Training, TVET, SD and Sustainable FTC industry.

Based on the systematic review in literature, this conceptual framework has been constructed to illustrate the relationship of key elements in each domain: **A** (STEM Education and Training), **B** (TVET), **C** (Sustainable Development), and **D** (Sustainable FTC Industry) for this research study. They are showing how STEM education and training can be carried by TVET under the concept of SD to enable a sustainable FTC industry.

In domain **A**, STEM education and training, Song et al. (2016) mentioned many countries as having stipulated the significance of STEM and its implementation in education. Hence, it is necessary to ensure the STEM concept and attitude are being well educated in the public by adopting a variety of activities in replacement of traditional lecture-based teaching strategies enriched with more inquiry and project-based learning approaches (Breiner, 2012). Under the learning theory of constructivism which encourages engagement, exploration, explanation, elaboration and evaluation (Bybee, 1997), De Groof et al. (2012) claimed it was effective for teaching integrated STEM, consisting of the integration of STEM content, problem-based learning, inquiry-based learning, design-based learning and cooperative learning. Within the trend in STEM education and training and STEM activity design, Odell (2014) described high-quality STEM education as promoting engineering design and problem-solving, which encourages an inquisitive spirit in project-based learning and develops minds-on, hands-on action with a collaborative approach to learning. Moreover, STEM education and training are usually embedded with technologies (TEL) such as mobile devices, smartphones, tablets, and electronic textbooks to support classroom teaching and students' self-regulated and effective learning (Lam, Lee & Yeung, 2015).

In domain **B**, TVET provides a lifelong learning pathway comprising the STEM elements of related sciences and technologies (UNESCO, 1999) that corelate to a broad range of occupational fields, services and production. This can take place at different college levels and may lead to professional qualification (UNESCO, n.d.). Henceforth, TVET is extending from VET to PET, where VET covers basic vocational education and training pegged at the upper secondary level and PET covers vocational education and training at a tertiary level, including degree-level programs. Eventually VET was rebranded to VPET in Hong Kong under the recommendation of the Task Force on Promotion of Vocational Education (HKSAR, 2020). In response to industry needs and to drive SD goals, education for sustainable development is highly recommended to be integrated in the TVET curriculum to promote creativity and innovative skills as well as problem-solving skills to meet the challenging industry. There is growing international recognition of education for SD as an integral element of quality education and a key enabler for SD (AIP Conference Proceedings 1887, 020076, 2017; UNESCO, 2020). In addition, to ensure responsive training in TVET, synergy with industry is an essential strategy for job relevant-learning to complement school-based learning by collaborative learning as well as skill acquisition on up-to-date technologies in the industry (Cara & Chatani, n.d.) under the global direction from SD.

Domain **C**, acts as a conceptual background for both domain B and D. SD comprises three pillars: environmental, social and economic sustainability (AIP Conference Proceedings 1887, 020076, 2017) which is the contemporary global issue that involving nations and countries on the planet. And the key principle of SD underlying is the integration of environmental, social, and economic concerns into all aspects of decision making (Dernbach, 2003; Stoddart, 2001). In particular, to enable the planet's survival and sustainability, it is important to drive the eco-concept of environmental sustainability, which mostly refers to humans' interactions with their ecosystem, which should meet the resource and service needs of current and future generations without compromising the health of the ecosystem (Morelli, 2011). Moreover, there are 17 goals under the SD, and those associated with this research study are industry innovation and infrastructure, quality education and training, climate action and life on land and under water, good health and well-being, affordable and clean energy, responsible consumption on resources and production, and sustainable cities and communities (United Nations, 2018). In brief, SD is the conceptual direction for TVET training to enable a sustainable industry thereon.

Finally, regarding the sustainable FTC industry in domain **D**, references have been made from the literature that indicated the FTC industry as being one of the largest polluters in the world that involving production from raw materials to textile and clothing as well as consumers' behavior regarding garment washing, ironing, and disposal (European Parliamentary Research Service, 2019), all of which results in deteriorating the eco-system of the planet. As such, there is an urgency to enhance the workforce with professional knowledge and green skill sets to cope with the challenges for a sustainable society to survive (Cedefop, 2012) by adopting and implementing eco-manufacturing processes in the FTC industry to make improvements along the SD (Heida, 2014). However, due to a shortage of skilled labor and STEM graduates that voiced out from the industry to satisfy the SD (Thbaut et al., 2018); therefore, TVET should encompass green technology that is economically feasible as well as environmentally friendly and can lead education and training to achieve SD in daily practice (AIP Conference Proceedings 1887, 020076, 2017).

To summarize, the conceptual framework in this study is using prediction–observation–explanation (POE) strategy (White & Gunstone, 1992) with the constructive, problem-based and project-based learning approaches and activities under STEM education and training to investigate whether or not STEM activities (Steampoweredfamily, 2020) can enhance the learning experience in TVET to enable a SD in the FTC industry. Finally, this research study anticipates "STEM-VET" as being promoted as a major innovation, focusing not only on trainees' needs today, but also setting the scene along the lifelong learning path to enable sustainable industry tomorrow.

Training courses in TVET for the FTC industry could be incorporated with STEM activities such as follows.

i) Color design and application (science related)

Trainees would be taught with professional knowledge of color lab-dip processing, color mixing and matching, fabric color swatches dyeing and finishing and then receive practical training in the color laboratory for application in a bulk fabric dyeing and finishing.

ii) Weaving, knitting and wearable technologies (technology related)

Trainees would be trained with contemporary weaving and knitting technologies in workshops such as the double weave of textiles used for the safety airbag system in automobiles, computerized circular knitting technology for functional (anti-bacteria and/or anti-odor) base-layer garment or lingerie and thermal conductive technology applied in textiles and wearable products with digital control.

iii) Seamless garment and shoe production (engineering related)

Trainees would be trained with seamless knitting technology for sweaters and active wear: different areas on sweaters are knitted with various types of functional yarns by specific machines to execute different functions like maintaining warmth, absorbing sweat, etc. Moreover, this area could also be adopted in the knitted sport shoes or sneakers for air permeability, shock proof and odor reduction.

iv) Yarn counts and textile quality evaluation (mathematics related)

Trainees would be taught calculation methods that employ the diameters of yarns, strength and torque of yarns, as well as the density of textiles. In the textile quality evaluation process, trainees would be trained with professional measuring, calculation and analysis in order to draw up any feasible solution regarding yarn characteristics, textile quality or performance issues.

With reference from literature of the planning of STEM activities in TVET courses, consideration has been made on project-based approach under the guidance of instructor, trainees have to explore, experience, construct knowledge, discuss and propose new ideas on application. For instance, smart functional textiles of water-resistant and wicking and quick dry (science and technology related), relevant functional fabric swatches would be sourced from the local textile market in Sham Shui Po, Hong Kong. Those fabric swatches encompass but are not limited to water-resistant fabrics with coating or lamination, wicking and quick dry nylon- or polyester-based fabrics. Trainees would be allocated a functional fabric swatch on which they would be required to carry out physical tests on water resistance and wicking performance during the lesson, followed by data recording by instruments and analysis by observation and mathematical calculations before arriving at the feasible proposal on the end-use product design and application in order to respond to the environmental problems.

To cope with the global trend in digitalization in workplaces, trainees could experience and practice with a STEM workshop on virtual garment design and fitting that utilizes computer software (technology and mathematics related). Trainees would learn and apply technical skill sets to design and illustrate a garment outfit through computer software and fit the outfit onto a virtual human figure – an avatar on a computer screen – prior to the actual pattern processing. Upon completion of the STEM workshop, trainees would be expected to master basic knowledge in virtual garment design, skills development, and virtual fitting, all of which are in line with the eco-concept of resources, lead time, as well as energy and resources saving under the umbrella of environmental sustainability.

Regarding the micro-electronics crossed over with textiles, trainees would be expected to learn about the wearable technology (technology and engineering related) on heat conductive textiles and products through the STEM activities in the workshop, they have to explore, experiment, observe and construct their knowledge under the guidance from the instructor and propose a new design and application during the group interaction and presentation.

To evaluate the effectiveness of the implementation of STEM activities in training courses or workshops, data and digital image (photographic or video) records of those STEM activities conducted during relevant lessons would be critically studied and analyzed. Last but not least, structured with open-ended question interviews on instructors and trainees would be convened, class observation and questionnaires would be adopted to collect information, and data from those classes would be analyzed to propose potential improvements thereafter.

3.2 Research Design and Methodology

The design of the research study is mainly initiated by the principal investigator by using the field study on treatment classes to investigate the effectiveness on learning experience upon STEM activities embedment. The principal investigator responsible for the entire design, setting of the treatment classes embedded with STEM activities together with the learning and teaching materials as well as facilities and equipment. With reference from literatures, theory of constructivism, mixed method approaches have been employed such as, data collection by interviews, class observation and questionnaire survey. Followed by qualitative and quantitative data analysis as well as triangulation of both data obtained prior to the interpretation and discussion. In the classroom or a learning environment, scaffolding can be employed to include modelling skill, providing cues or hints, and adopting materials or activity (Copple & Bredekamp, 2009).

From the literature review, Creswell (2013) mentioned different types of mixed method research designs; they are relatively new in social and human sciences as a distinctive research methodology. A mixed method involves the collection and systematic analysis of both qualitative and quantitative data. These two forms of data can be integrated into the design analysis through connecting, merging or embedding the data to achieve an optimal result. The basic types of mixed method designs are convergent parallel mixed methods, explanatory sequential mixed methods and exploratory sequential mixed methods (Figure 4).

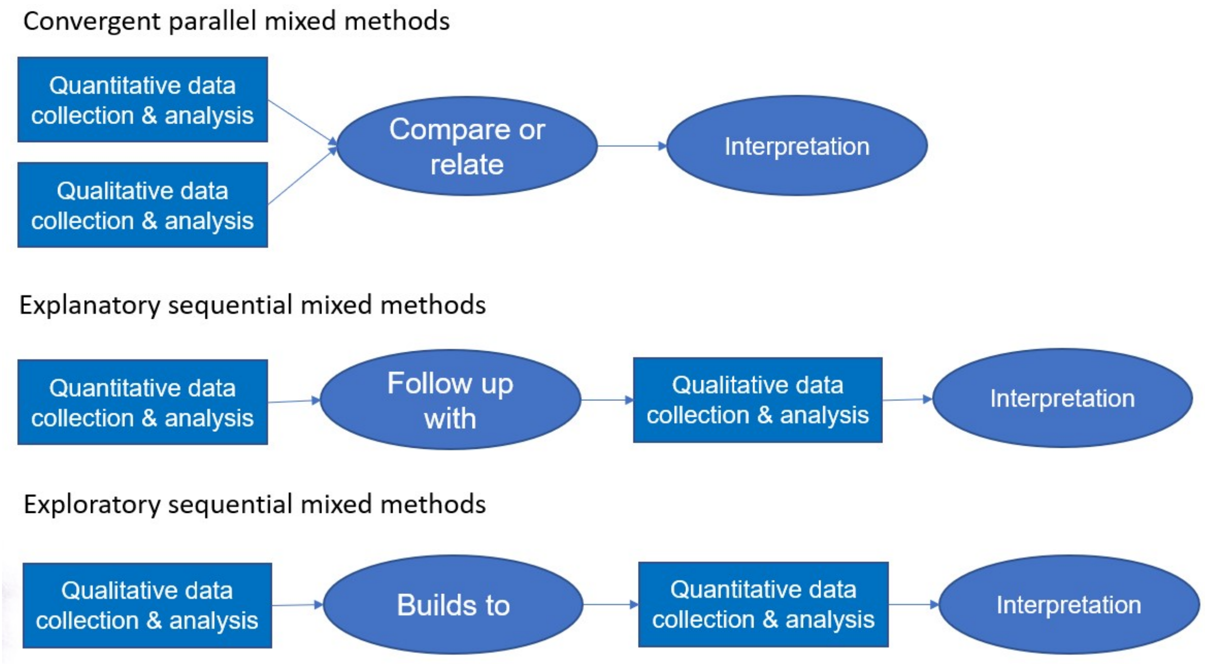


Figure 4. Mixed method research designs (adapted from Creswell, 2013)

3.2.1 Convergent Parallel Mixed Methods

In this approach, the researcher or investigator collects both qualitative and quantitative data during the study period, analyses those data separately and then compares and triangulates the results to check whether the findings confirm or refute each other. The key assumption of this approach is that both qualitative and quantitative data render different kinds of information. Detailed views are most often solicited from participants using qualitative means, while scores are obtained by instruments that provide quantitative data.

The data collection method for a qualitative approach can involve interviews, observations, documents and records. By contrast, the data collection method for a quantitative approach can be via survey, statistical tests and questionnaires. The validity of using a convergent approach should be based on both forms of the database for comparison and triangulation (Creswell, 2013).

3.2.2 Explanatory Sequential Mixed Methods

There are two sequential phases in this approach. Quantitative data is collected and then analyzed in the first phase; this analysis is used to plan the next phase. Those quantitative results can typically locate the types of participants selected for the qualitative phase of the study. The overall intention of this approach is to utilize the qualitative data to explain in more detail the initial quantitative results.

The data collection method proceeds in two distinctive phases: a rigorous quantitative sampling, followed by the qualitative phase. Using the quantitative results to plan for the qualitative follow-up actions helps elaborate the initial quantitative results in more details. This method is easier to accomplish than the convergent approach because one database builds on top of the other, and the data collection exercise can be spaced out over a period of time (Creswell, 2013). The validity needs to be established from the quantitative measures so as to discuss the validity of qualitative data and the key strength of this design study. There is indeed an in-depth qualitative follow-up process within the entire approach (Creswell, 2013).

3.2.3 Exploratory Sequential Mixed Methods

This approach is a reverse of the explanatory sequential mixed methods in which the researcher or investigator starts with the exploration in the qualitative phase and then adopts the analyzed findings in the second quantitative phase. Hence, the second phase database shall be built on top of the initial database with an intention to develop and yield better measurements with a specific sample of participants in the quantitative phase. The researcher will usually first collect focus group data by qualitative means, analyze the obtained results and then develop an instrument based on those results prior to the application to a group of participants (Creswell, 2013). A researcher has to cross-check the validity of those qualitative data as well as the quantitative numerical scores and must ensure that sample from the qualitative phase is not embraced in the quantitative phase in order to avoid unnecessary duplication of responses during the entire study process.

With reference to Creswell's (2013) theoretical framework, this research project adapts the convergent parallel mixed methods approach as the skeleton of the research design. Convergent parallel mixed methods are the best approach for this project because it is less time consuming and more appropriate as well as comprehensive to measure the effectiveness of the topic in this research study. Moreover, triangulation is usually suggested by researchers to adapt among either different qualitative approaches or between quantitative and qualitative methods (Sofaer, 2002). It is a valid procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell & Miller, 2000, p.126). Triangulation can be used to verify the industry representatives' and trainers' views and intended learning outcomes of the training courses against the trainees' overall performance through both parallel qualitative and quantitative methods. This endeavor should provide a comprehensive and effective means to perform the research study. The research methodology applied in this project will be a combination qualitative and quantitative triangulation study on STEM career employers and TVET trainers and trainees; these parties may provide the researcher or investigator with valuable perspectives and precious data from their own platforms.

Qualitative research is normally inductive in nature, and researchers generally explore meanings as well as insights within a given situation or design setting (Levitt, Motulsky, Wetz, Morrow, & Ponterotto, 2017; Strauss & Corbin, 2008). It involves purposive sampling, structured with open-ended question interviews and a range of data collection and analytical techniques (Dudwick, Kuehnast, Jones, & Woolcock, 2006; Gopaldas, 2016). Qualitative research is an umbrella term that refers to the theoretical perspective designs such as, phenomenology, narrative, ground theory, case study, action research, ethnography, historical research and in-depth content analysis (Creswell, 2009; Hancock, Ockleford, & Windridge, 2009).

According to Cibangu (2012), qualitative research comprises ethnography, logic, discourse analysis, case study, open-ended interviews, ground theory, biography, participant observation, focus group and historical research, among other approach. The methods include interviews, classroom observations, diaries and questionnaires to solicit, analyze and interpret the data content of visual and textual materials and oral narrations (Zohrabi, 2013).

Berg and Howard (2012) described qualitative research as concepts, metaphors, meanings, symbols as well as a description of things. The instruments used in qualitative research are normally structured or semi-structured interviews and participants' observation. Field notes and audio and video records are usually employed for data collection from participants in the design settings. Hence, the advantage of qualitative research is it provides abundant data about real-life people and the situations to which they are exposed (De Vaus, 2014, p. 6; Leedy & Ormrod, 2014). Furthermore, Conger (1998) claimed the advantages of conducting qualitative research could provide a clear vision to a researcher on what to expect, an in-depth and detailed evaluation on issues and subjects covered, cost saving on sample batches, more content for the generation of new ideas and implications and more compelling and powerful results. Disadvantages raised by Richards and Richards (1994) include that qualitative research is not statistically representative, the data, findings and outcomes are limited and not generalizable to a larger population; unseen data might disappear from the research process; researchers could have a negative influence on data collection; and the process strongly depends on a researcher's skills, which could be easily affected by personal idiosyncrasies and biases.

Regarding the quantitative research approach, Bryman (2001, p. 20) argued that this approach emphasizes numbers and figures in the collection and analysis of data. One of the advantages of the quantitative research method is the use of statistical testing for the research descriptions and analysis reduces the researcher's required time and effort to describe the results. Research data such as percentages, numbers and measurable figures can be calculated and analyzed by a computer system, for example the Statistical Package for Social Science (SPSS; Connolly, 2007, p. 2–34; Gorard, 2001, p. 3). This possibility saves a lot of energy and resources for the investigator.

Owing to the limited size of the data pool from interviewees and participants in this research study, the mixed research approach of qualitative and quantitative will be more efficient. Between these two approaches, qualitative data could be more dominant because an abundance of informative data might be collected from industry representatives, trainers and trainees. On the other hand, numerical data collected from questionnaires can be used to further verify the effectiveness of the STEM activities conducted in the courses.

In Maxwell (2013), his interactive model of research design consisted of five components: goals, conceptual framework, research questions, methods and validity. Goals were concerning why is the study worth doing, why the researcher wants to conduct the study as well as the results should be care about? Conceptual framework is indicating what does the researcher think that going on with the issues, settings or people plan to be studied? Followed by specific research questions that showing what researcher wanted to learn or understand during the study. Then methods come with what approaches and techniques will the researcher employed to collect and analyze the data. It encompasses the relationships amongst researcher and participants; setting, times and places of data collection, data collection methods; data analyze strategies and techniques; last but not least is the validity which deals with how might the results and conclusion be wrong as well as the credibility of the results. Below figure presents the interactive model of research design from Maxwell (2013).

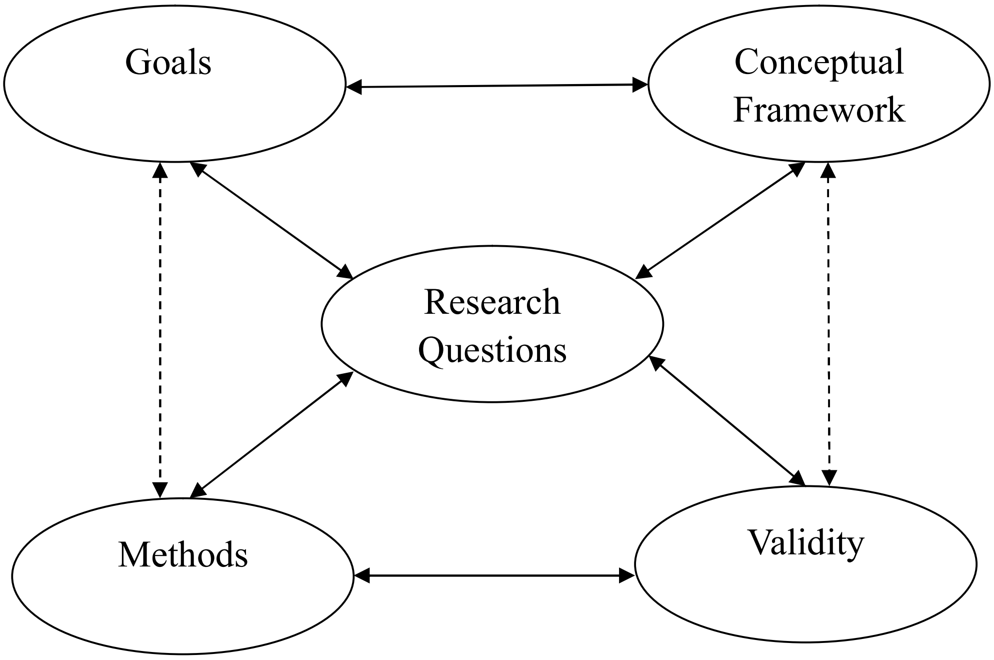


Figure 5. An Interactive Model of Research Design from Maxwell (2013)

As aforementioned, this research project would be carried out in a mixed method approach, and the research design could make reference to Maxwell (2013) interactive model of research design that illustrated in the Figure 5.

The ultimate goal of the study design in this project is to foster continuous improvement in learning and teaching methods imparted in the in-service training courses that enable trainees to acquire up-to-date knowledge, skills and competence to participate in and evolve a sustainable FTC industry. Figure 6 presents how this research project adapts the concept of Maxwell (2013) interactive model of research design.

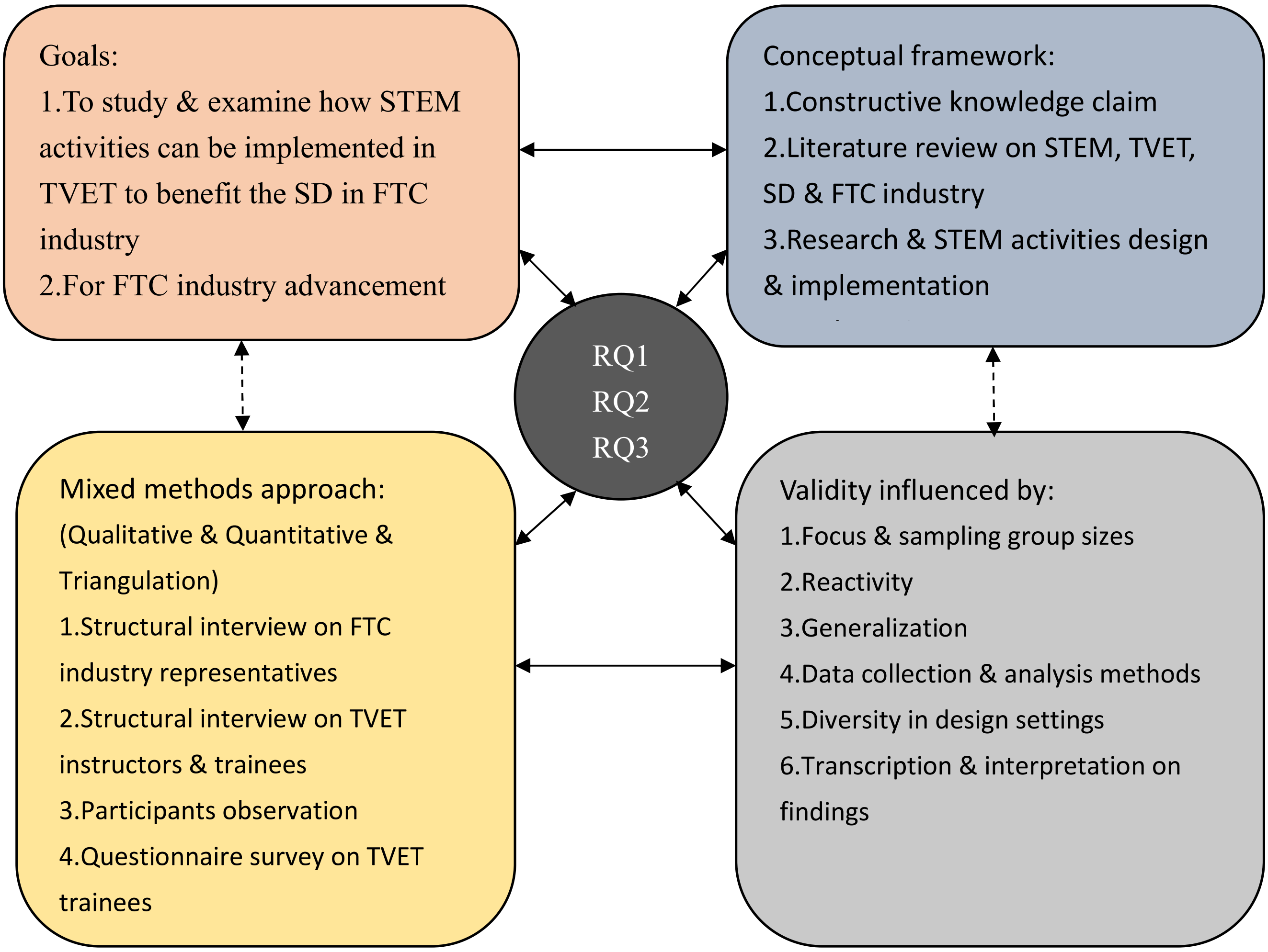


Figure 6. The research design showing interrelationship of components in this study

Knowledge claim	Constructivist assumption	Group learning and knowledge building to propose new ideas on application
Research approach	Mixed methods	Qualitative is to gain in-depth perspective whilst Quantitative is to generalize to a population
Strategies of inquiry	Convergent parallel	Triangulation among data collected and check whether they confirm or disconfirm each other

Research methods	Interview protocols Participant observation Questionnaire survey	Structured interviews (F2F & Phone) Observation on treatment classes Likert scales with open question in questionnaire survey

Table 1. The Framework of Methodology

3.3 Timeline on Research Study

Table 2 presents the timeline for the research study; it is spread out over three years (a total of 12 quarters). Quarter 1 is from January to March, quarter 2 is from April to June, quarter 3 is from July to September and quarter 4 is from October to December.

Timeline	**2018**				**2019**				**2020**			
Quarter	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Literature review	●	●	●	●	●	●						
Proposal writing and presentation			●	●	●	●						
Design of interview protocols and questionnaires					●	●						
Facility and resource preparation					●	●						
Pilot study					●	●						
Employer interviews						●						
Instructor interviews						●	●	●				
Trainee interviews						●	●	●				
Participant/class observations								●	●			
Questionnaire and data analysis								●	●			
Thesis writing						●	●	●	●	●	●	
Thesis submission											●	
Viva examination												●

Table 2. The milestone for this research study

3.4 Pilot Study on Focus Group

Prior to the commencement of the research study, a 4-week pilot study on the let-out process of fur and leather design will be used to test the facilities and equipment during the demonstration and practice in the activities. Besides, soft skills (Chinese and English language instructions in the demonstration, practical activities and evaluation) will also be pre-tested to evaluate the trainees' competence in responding to them.

This study was approved by Human Research Ethics Committee (HREC) in the Education University of Hong Kong (EdUHK) on 29 January 2019. The principal investigator subsequently conducted a pilot study on a small focus group of four trainees in March 2019 in the STSC to test run a STEM activity launched in the fur and leather design lesson. The principal investigator developed this pilot class to study, pre-test and solicit the initial response from the focus group on the STEM activity implemented in the lessons. During the former lessons, the principal investigator delivered theoretical knowledge on fur and leather design to trainees, followed by a demonstration and experience on the simulated let-out process, which is the major and unique manufacturing procedure in the fur industry. The principal investigator sourced different colors and qualities of real fur strips and samples from the market for the STEM activity in the lesson. During the activity, the principal investigator simulated the let-out process, which involves cutting fur strips and then re-engineering them using mathematical calculations that determine the optimal arrangement for design and manufacturing cost in order to form an aesthetic and functional virtual fur garment.

Given that STEM is a kind of inquiry-based learning approach in education and training, the trainees were given a real problem in fur design with regard to the aesthetics and cost of the prototype. The question was how to make use of the let-out process to optimize the aesthetic look and cost of the virtual prototype. STEM elements developed and modified by the principal investigator encompassed the simulation of the let-out technical process on paper, re-engineering and shaping of panels as well as mathematic calculation during re-engineering and shaping processes to arrive at desirable outcomes. Each trainee was provided with all the supplies they needed, including A4 white paper, pencils, a cutter, a protractor and a calculator. They had to follow the guidelines and steps given by the instructor to complete the let-out process. The real learning material, fur strips, were replaced by plain paper for trainees to practice, cut into 0.5 cm wide paper strips with an angle (≤ 30°), then calculate and make optimal angular arrangements (≥ 50°) to fit for the two-dimensional (2D) simulated prototype. By experiencing this simulated let-out process, trainees would be expected to understand the product design and develop a fur garment in a real manufacturing context.

Figure 7 shows the simulated let-out process on paper before the optimal re-arrangement of strips. Figure 8 shows the simulated let-out process on paper after the optimal re-arrangement of strips. Figure 9 shows the back side of the fur skin before the let-out process. Figure 10 shows the back side of the fur skin after the let-out process and the reunion of fur strips to form an aesthetic slim rectangle.

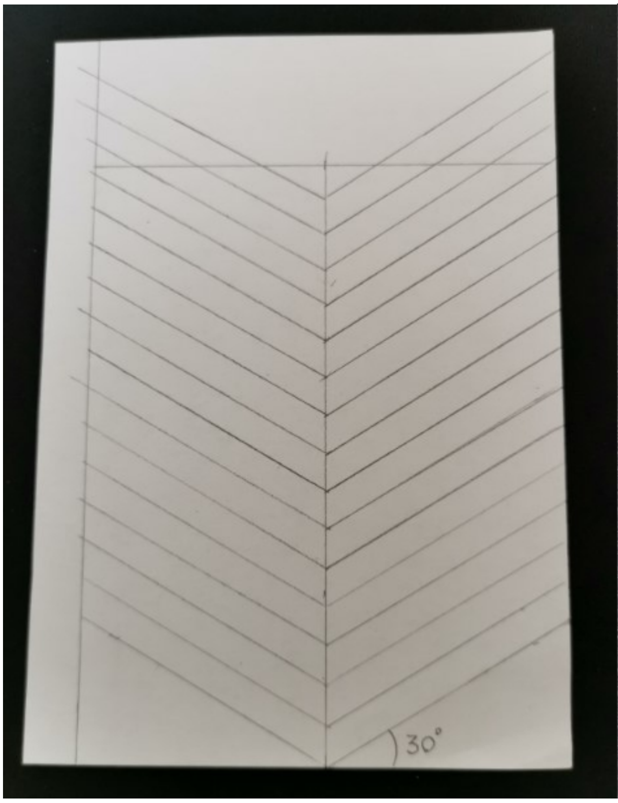


Figure 7. Blueprint before let-out process

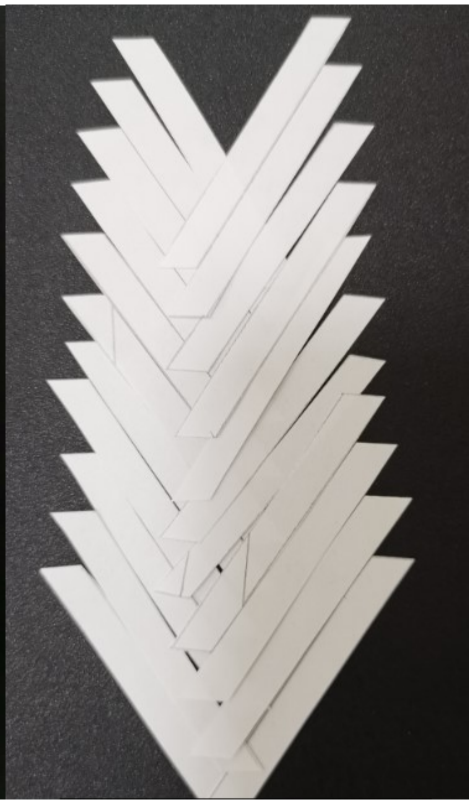


Figure 8. Blueprint after let-out process

Figure 9. Fur strip before let-out

Figure 10. Fur strip after let-out

Regarding the evaluation, the focus group of trainees was verbally tested on their bilingual (Chinese and English) ability prior to the quantitative survey. A sample 5-point Likert questionnaire (range from point 1 strongly disagree to point 5 strongly agree) – written in English and Chinese – was adopted as a quantitative instrument. It comprised 15 questions and was given to the focus group to obtain their feedback after the let-out process STEM activity (Appendix C shows the questionnaire protocols). To ensure its reliability, the questionnaire had been discussed and consulted with a FTC industry representative who was also a TVET instructor with regard to the contents, language used and appropriacy before administered to the participants in the pilot class. Overall, one trainee strongly agreed that the STEM activity could motivate and enhance their learning outcomes in the training course, while the remaining three trainees agreed, but not as strongly. Since there were only 4 questionnaires returned after the administration, it was quite meaningless to analyze the data via SPSS system due to too small size batch. Rather, the principal investigator interviewed the focus group after the STEM activity; they commented that the STEM activity was meaningful and helpful to them as a whole in the training course. However, due to a limitation on the small sample size of the focus group, these data only serve as an initial reference for the subsequent research study.

For the treatment classes, they can base on the experience from pilot study. Structured with open-end question in face-to-face interviews with employers and representatives from chambers or industry will be carefully planned, recorded, transcribed, coded and analyzed. The principal investigator might then be able to solicit more insightful views on STEM and TVET that benefit the FTC industry as a whole.

On-site class observations, field notes, and visual data like digital or photographic images and video records can be utilized to evaluate TVET trainers as well as trainees' performance. These methods will allow for immersive understanding as well as analysis along the entire research process. The ultimate goal is continuous improvement in learning and teaching in which trainees can keep up-to-date professional knowledge and skill competence in the FTC industry.

Structured interviews with open-ended question on trainee focus groups can be carried out via phone call interviews. Questionnaires (on site and/or online) that collect the trainees' views on the effectiveness of STEM activities can be recorded for in-depth analysis with the aim to respond to the research questions.

A coding system will be applied to ensure qualitative data and access are safely encrypted and kept confidential as well as to facilitate systematic data categorization and analysis. Quantitative data can be analyzed by using Pearson correlation coefficients, reliability, *t*-test, analysis of variance (ANOVA) and other appropriate methods through the SPSS system to justify any conformance or not in the research study.

3.5 Participants/Respondents and Sampling Method

The individuals invited to participate in this study are employers, FTC industry representatives, instructors from vocational institutions and trainees from the institutions. All of them were adults over the age of 18. The FTC industry representatives represent five individuals who had interest were chosen through the principal investigator's network in employers, enterprise, design associations, worker unions and TVET organization for maximum coverage in the face-to face interviews. There were four FTC trainers and instructors. They were also invited from full-time and part-time posts who had interest via the principal investigator's connections in different TVET organization for face-to-face interviews to avoid unnecessary bias. Finally, seven trainees who had interest in a phone interview were also picked up from those participants enrolled in the treatment classes by the training organization. (Appendix A shows the respondents' detail list) The principal investigator had no direct working relationship with the FTC industry representative and trainers. Also, the principal investigator had no knowledge about the trainees; indeed, they were all recruited directly by the training organization. The following table shows the breakdowns of the respondents for reference.

Respondents	No. of Males	No. of Females	Total
FTC industry representative	3	2	5
TVET trainer/instructor	1	3	4
TVET trainee	3	4	7

Table 3. Group and gender distribution of the respondents

A focus group of the structured with open-ended questions interview on STEM career representatives from the FTC industry will serve to gather contemporary views and insights about STEM activities in TVET for in-service practitioners in responding to the current and future needs as well as manpower capacity. Based on the analysis of their views and insights, in-service training course content and settings will be designed and incorporated with the STEM activities for this research project. The training content, STEM activities and pedagogy will then be carried out, reviewed and fine-tuned for continuous improvement during subsequent lesson delivery. Figure 11 presents a simple diagrammatic illustration that shows the Plan-Do-Check-Act (PDCA) cycle that indicates how training will be continuously improved.

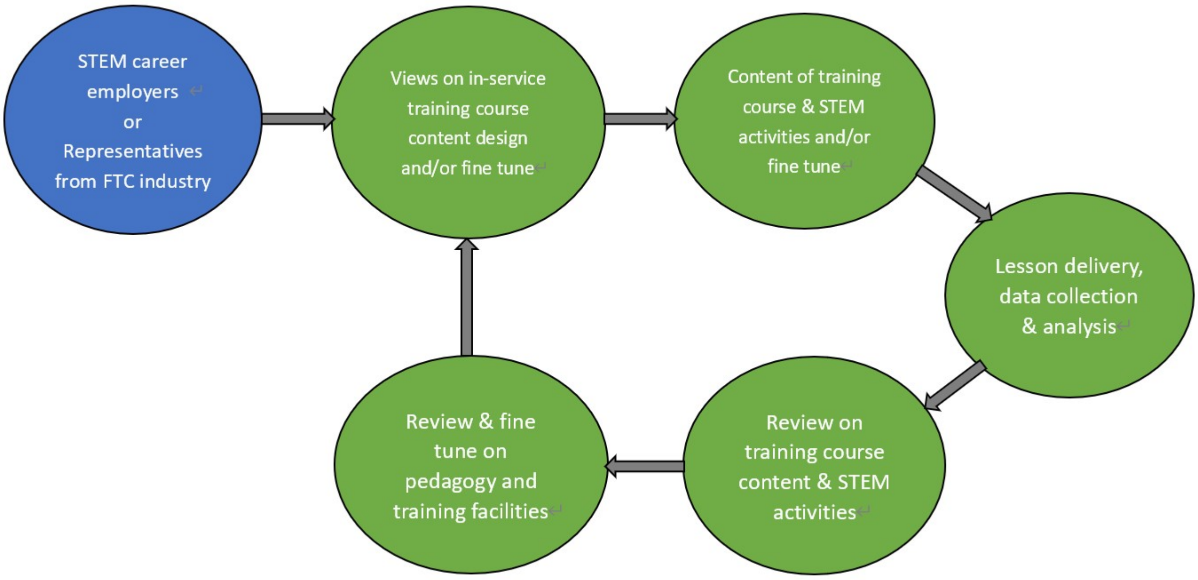


Figure11. Plan-Do-Check-Act (PDCA) cycle on the continuous improvement of training

3.6 Research Instruments and Tools Development and Operation

Under the mixed method approach, the instruments and tools adopted in the research study are mainly face-to-face, structural interview with open-ended question to ensure relevancy and consistency to research questions, phone call interviews, classroom observations, photographic and video recordings for latter analysis and questionnaires survey with relevant consent forms for participation in this research study. The instrument and tools' design were based on the pilot study and consultation from the industry representative who was also a TVET instructor.

To obtain fruitful and reliable results from this mixed methods approach, the principal investigator arranged interviews with FTC industry stakeholders or representatives, trainers, and instructors as well as triangulating focus groups from trainees. All interviewees were full-time and part-time adults working in the relevant sectors of the industry and training organizations. For the qualitative survey, with consent from the interviewees, the principal investigator conducted face-to-face verbal interviews and phone call interviews from August

2019 to March 2020.

The principal investigator made an individual appointment with interviewees at a convenient venue to conduct the face-to-face interviews; these meetings adopted well-prepared interview protocols and were recorded. Each interview was transcribed in detail and reviewed to obtain relevant views and comments. The interview protocols are presented in Appendix B for further reference. Also, Appendix D shows the summary of transcriptions while Appendix E records the transcription from focus group interviews respectively.

The first section was the interviews for 5 FTC industry representatives, they were the representatives from employers, companies, enterprises, authorities, associations, worker unions and universities. The interviews protocols included 25 structured and open-ended questions from 6 sections: the FTC industry perspectives; professional recognition of TVET; STEM elements and activities in the TVET curriculum; the relationship between TVET and sustainable industry; attitudes, skills and competence of trainees from TVET; and their views on future development and advancement in TVET. Participants' views and comments were collected for reference.

The second section was the interviews for 4 FTC training representatives, they were the representatives from TVET organizations which were running the full time and part-time modes of training courses. The interviews protocols included 14 structured and open-ended questions from 6 sections: the implementation of STEM activities in TVET; difficulties and constraints in practical workshops; resource and facility requirements; trainees' learning attitudes and reception towards STEM activities; outcomes and effectiveness in overall performance; and their views on future development and advancement in STEM activity. Participants' views and comments were again collected for reference.

Given that this project encompassed action research, the principal investigator who also instructed two of the treatment classes, collected observations and findings during the STEM workshop delivery. These results are provided in chapter 4.3.

In the last section, the principal investigator provided questionnaires to 39 trainees (full time and part-time practitioners) and conducted phone call interviews with 7 trainees to wrap up the research study for analysis, triangulation, and interpretation (Appendix C shows the questionnaire protocols). Regarding, the questionnaire protocols set for the trainees in those treatment classes, there were 14 questions to collect feedback covering sexes, ages, working status, attitude towards STEM activities, affection, usefulness and practicability as well as open-end comments and views. For the phone call interview protocol set for trainees, it consisted of 5 sections with 12 structured and open-ended questions in which covering their comments and reflection on learning attitude, participation, receptivity of STEM activity, outcomes and effectiveness in performance, and also views about advancement in STEM activity for more in-depth feedback on their learning experience.

All interview questions and procedures were developed by the principal investigator with reference to the standard qualitative methods in educational research (see, e.g. Liamputtong and Ezzy, 2005; Patton, 2002). The validity, reliability and credibility of the interview, class observation and questionnaire protocols had been carefully considered and undergone the reference from the pilot study on the fur “let-out process” STEM activity as well as consultation with the FTC industry representative who was also an expert in TVET training about the contents and language used prior to the administration which was also mentioned similarly in Taherdoost (2016).

Besides the above major instruments adopted in the research study, other minor instruments such as computer laptops, tablets and SPSS software have also been used for data processing and analysis.

3.7 Data Collection Methods

As mentioned before, a mixed method approach was utilized to investigate the respondents' attitudes and perceptions on the effectiveness of STEM activities embedded in TVET training courses for the sustainable FTC industry. The methods of data collection can be summarized into the following six steps: consent to participate in research; face-to-face/phone interviews with FTC industry representatives; TVET instructors and TVET trainee representatives; class observation as well as questionnaire survey. An explicit narration on the aim and context of the research project, pretest on language ability had been done to ensure clear communication; onsite classroom observation and digital images recording as well as distribution of questionnaire survey at the end of the workshops for further analysis. Below figure shows a summary of the workflows for data collection.

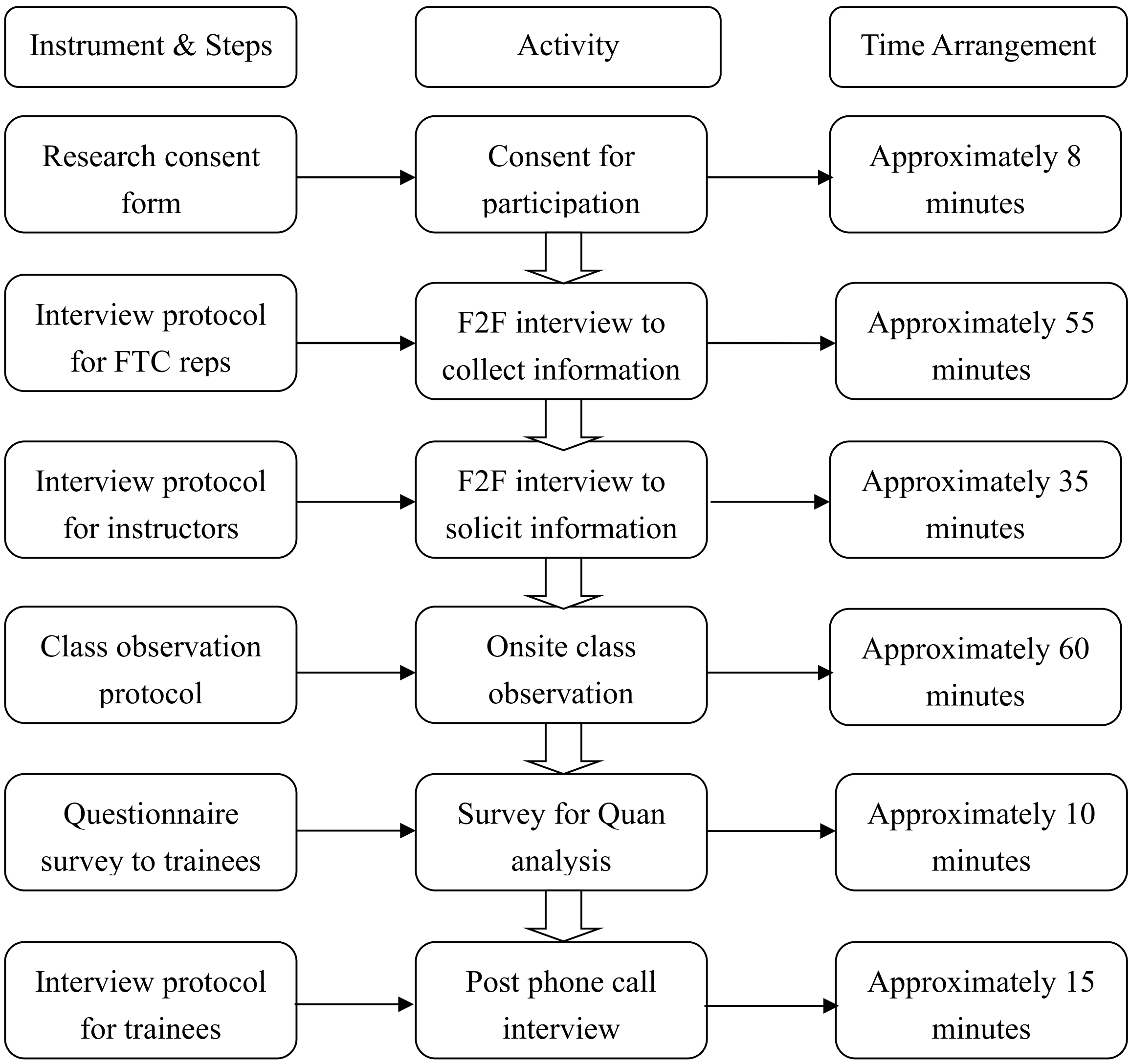


Figure 12. Summary on data collection flow chart

3.8 Data Analysis Methods

For the qualitative data collected from face-to-face and phone call interviews, those data will be transcribed and then encoded by parent and child codes into categories and sub-categories and threads for systematically analysis according to the context and elements in the research questions and sub-questions. In the questionnaires, a Likert scale scoring from one (strongly disagree) to five (strongly agree) was adopted separately to reflect trainees' views regarding their learning interest, perception, receptivity, affection, usefulness, and own opinions towards the research topic. By using SPSS (Pearson Correlation, Independent *t*-test, Anova and Post-hoc tests) to analyze the quantitative data obtained, which could also respond to the research questions and sub-questions. Finally, side by side triangulation on qualitative data including data from class observations and quantitative data could render comprehensive cross checking on conformity or disconformity among all data (see p.151-156).

3.9 Validity and Reliability

Although the term "Reliability" is a concept adopted for testing and evaluating quantitative research, but the idea is most often used in all kinds of research (Golafshani, 2003). Lincoln and Guba (1985) stated that validity could not be existed without reliability in a research study. So, reliability is essential for study, but it is not sufficient unless combined with validity (Wilson, 2010). As such, reliability and validity are conceptualized as trustworthiness, rigor and quality in qualitative paradigm during research (Golafshani, 2003). While the credibility in quantitative research depends on instrument construction, however, in qualitative research, "the researcher is the instrument" which depends quite a lot on the ability and effort of the researcher (Patton, 2001, p.14). This research design and set up has been controlled by the principal investigator who is a TVET trainer with profound industry experience and hence the reliability and validity of methodology as well as instrument used have been well considered and ensured.

3.10 Ethical Considerations

Ethical issues normally refer to situations or problems that require a person or organization to choose among alternatives that must be evaluated as ethically right or wrong. It concerns but is not limited to data privacy, collecting and encoding methods, handling data as well as the consistency in data processing. In this research study, upon receiving ethical approval by HREC in EdUHK, the principal investigator prepared the relevant consent forms – with detailed research objectives and methodology – and distributed them to the parties concerned in the research study. All participants were informed about the purpose of the research, their right for withdrawal before or during the process without any penalty, and free to make comments as well as respond to the questionnaire survey.

All the data (written, verbal, field notes, visual and audio) collected have been safely encrypted and locked up separately and kept confidential; these data can only be accessed by the principal investigator and his supervisors. The names of the interviewees and participants have been encoded for privacy and analysis purpose in the research study. Pseudo names were adopted for FTC industry representative as FTC_00 (01 to 05); TVET trainer as TRR_00 (01 to 04) and trainee as TRE_00 (01 to 07) for ethical reasons throughout the analysis. The entire research practice was applied consistently to each participant, including the reference citation and acknowledgement in the research project. Upon request from the participating TVET organization, a verbal report would be provided for their information and reference.

The validity of research relies on its credibility and transferability for the purpose of continuous improvement in TVET curriculum. In order to maintain consistency and fair consideration of the medium of instruction (MOI) across all the treatment classes, trainers and instructors would review the trainees' list and see which MOI should be appropriate during delivery so as to eliminate any undue influences that resulted from language benefit or language barrier amongst the trainees in the treatment classes. The alignment including MOI, PowerPoint presentations, supplementary notes and worksheet for the STEM activities in the workshops.

3.11 Consent Form for Organization and Participants

Upon receiving approval from the HREC on all the related forms and documents, consent forms and relevant document have been prepared and disseminated to all involved parties. Those parties are representatives from the FTC industry stakeholders, such as employers, companies, enterprises, authorities, associations, worker unions, universities, trainers and instructors as well as trainees from the TVET organization. As mentioned above, the principal investigator first interviewed FTC representatives, followed by instructors and lecturers from vocational training organizations. When they were reached and invited to participate the research study, a clear narration on the nature of the research study was delivered to them and their consents of participation had been sought. They provided invaluable views and comments to the principal investigator for reference. During the data and information collection processes, all trainees were informed about the nature of the research study and their consents had been sought to participate in the study voluntarily. All the consent forms and relevant documentation are presented in Appendix K for further reference.

3.12 Implementation of Research Study

After planning the course content, STEM activities and relevant set up, the principal investigator prepared the teaching and learning materials, set up STEM activities and conducted evaluations during the entire research period from August 2019 to March 2020.

3.13 Plan for Classroom Implementation and Operation

A blended teaching approach – demonstration and practical activity – will be adopted in the course delivery. In-service training classes in Clothing Industry Training Authority (CITA), The Woolmark Company (TWC) and Hong Kong Wearing Apparel Industry Employees General Union (HKWAIU) will be selected for the research study. There are around 10 to 15 students in each in-service training course, and each lesson is around 2.5–3 hours. Trainees from in-service classes will be taught through conventional lectures, demonstration and experience the STEM activities during the lessons from August 2019 to March 2020. The instructor who is going to teach and train them throughout the whole lessons in the course will consistently collect and analyze the intermediate and overall results during the activities so as to evaluate the intended learning outcomes.

First, the principal investigator will plan and design the course contents for the treatment classes to last approximately three hours per lesson. Within the treatment classes, there will be STEM activities (three-dimensional computer-aided design [3D CAD], smart and functional Sportwool textiles, heat conductive technology on fabric and garment products) embedded in the courses. The number of hours involving lecture delivery, demonstrations and practical STEM activities will be clearly denoted.

Second, the principal investigator will draft a scheme of work (SoW)/teaching plan and provide detailed breakdowns of teaching, demonstrating, practicing and group discussion hours for instructors to follow. Furthermore, teaching and learning materials like PowerPoints, notes and supplementary handouts, written and practical assignment sheets and so on will be well prepared and aligned to the SoW for each lesson delivery (Appendix J).

Third, the principal investigator will start to search for test materials such as heat conductive garment products, merino wool textiles and smart functional fabric swatches from the contemporary fabric and material market, and equipment as well as devices will be set up in the lessons embedded with STEM activities for trainees to explore, experience, observe, and practice under an instructor's guidance.

In science related learning, opportunities for observation are clearly essential for students to build up their own sense of reality (Kearney, Treagust, Yeo, & Zadnik, 2001; Tomkins & Tunnicliffe, 2001). Inquiry into the real-world phenomena experienced by students in daily life is central to school science education, and under the learning mode of guided inquiry, students follow the directions from instructors to complete inquiry learning tasks for scientific investigations (Martin-Hansen, 2002). During the practice of scientific related experiments, in which typically involve the processes of making prediction, observation, and explanation is an integral and vital part helping students to link scientific theories with the real-world, develop their technique in using instruments and equipment as well as motivate learning atmosphere with hands-on experience in science education (Braund & Driver, 2005; Colwell & Scanlon, 2002; Scanlon, Morris, Di Paolo, & Cooper, 2002; Wu, Yeung, & Kong, 2007). Henceforth, under the inquiry learning approach of STEM, the principal investigator will adopt a prediction–observation–explanation (POE) inquiry-based learning mode in the treatment classes. Prediction, data recording, manipulation and observation will be led and taught to the trainees for analysis and explanation as well as knowledge construction through the activities, so as to derive a feasible solution to the question raised in the practical assignment. According to White and Gunstone (1992), POE is a strategy normally used in science; it encourages students to predict, observe, discuss and analyze in order to motivate them to explore new concepts and insights. This strategy usually requires students to predict what would happen first, which they might not observe carefully, then write down the predictions as a motivation to find the answer. It is useful to uncover any misconceptions and provide information for group discussion as well as explaining their former predictions for later constructive decision making. Hong, Hwang, Liu, Ho and Chen (2014) claimed from their study that POE mode of inquiry was suitable for implementing at an intelligent mobile device to enhance young students' interest and continuance intentions with respect to the learning of science. It seems suggesting appropriacy to adopt in the design of treatment class Smart Technologies and Thermal Conductive Textiles in this research. However, a potential limitation is that students are more likely to learn through observations that could confirm their predictions. Consequently, the principal investigator hope that the trainees can learn through the practice of STEM activities implemented during the lesson and satisfy the needs and the real application in their careers.

3.14 Development and Preparation of Learning and Teaching Materials

With regard to lesson contents, theory and knowledge-based lessons comprised the early part of the training course, whilst the STEM activities occurred near the end. The STEM activities included simulated practice of smart technology on heat conductive textile and wearable products; practical workshops on smart functional textiles that embrace water-resistant textiles; wicking and quick dry functional wool textiles; and the use of 3D fashion software in virtual garment design, proportional figure illustration and virtual fitting. All of these areas are prevalent in the FTC industry.

During the practical lessons, demonstration was conducted by the instructor and trainees were guided, coached and worked individually or as a small group to complete the activities. The teaching materials included but were not limited to informative PowerPoint presentations, fabric swatches, testing equipment and devices, computers and 3D CAD software, VR headset, mobile apps, power banks and project briefs. The trainees utilized these instruments to carry out the experimental works, observe and analyze data obtained during the lesson and then interpret the overall results and provide new proposals with application to the instructor in class. This approach will ideally allow trainees to show understanding and master the know-how on STEM elements experienced and knowledge construction during the course for an authentic application in the contemporary FTC industry.

3.15 Procedures on the Preparation of Treatment Classes

The preparation period for the treatment classes lasted approximately seven months starting from August 2019. Preparation works comprised but not limited to generate teaching materials, PowerPoint presentations, handouts and worksheet and obtaining real objects for demonstration and practice, equipment and tools in the STEM workshops.

The following was the process on development and preparation of teaching and learning materials for treatment classes. In treatment class A, Smart Technologies and Thermal Conductive Textiles, the demonstration materials such as, VR headset, mobile device with the installed temperature controlling apps, heat conductive scarf and heat conductive vests were sourced from the market and tested before the STEM workshop. The related PowerPoint on the smart technologies, teaching notes and project worksheet were well-prepared for the workshop (Figure 13-17). The principal investigator had set up the equipment and devices in the STEM workshop before the lesson. STEM elements incorporated in the workshop were mobile apps, graphene heating vest and virtual scenario created by VR headset. Given a challenging problem concerning SD existed in FTC industry, and under the advocacy of project-based learning (PBL) approach, trainees had to form small groups for practical exercise under the practice of POE inquiry-based learning method to predict, observe, construct own knowledge, explain, and propose a new application during the STEM activities. The principal investigator invited a professional observer to help recording down the observations of trainees during the workshop and taking the photographic and video records for reference.

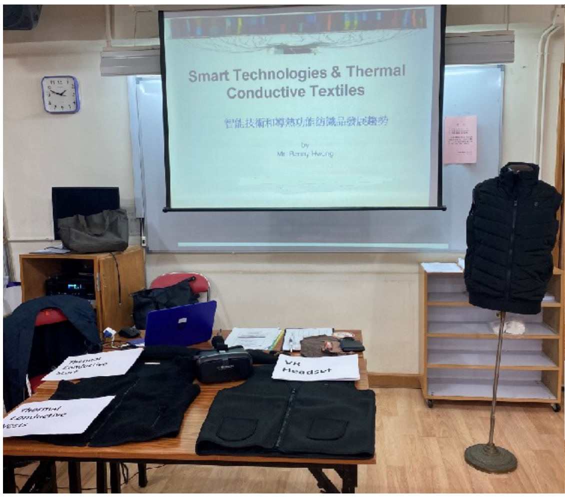


Figure 13. PowerPoint

Figure 14. Teaching materials

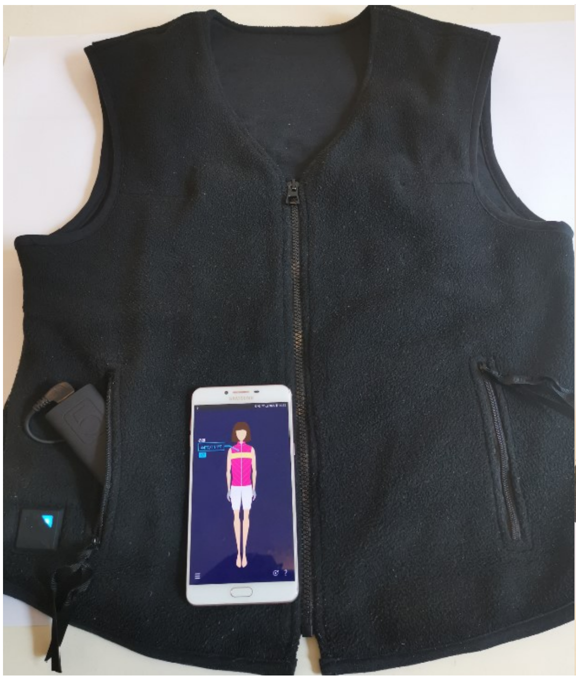


Figure 15. A heated vest

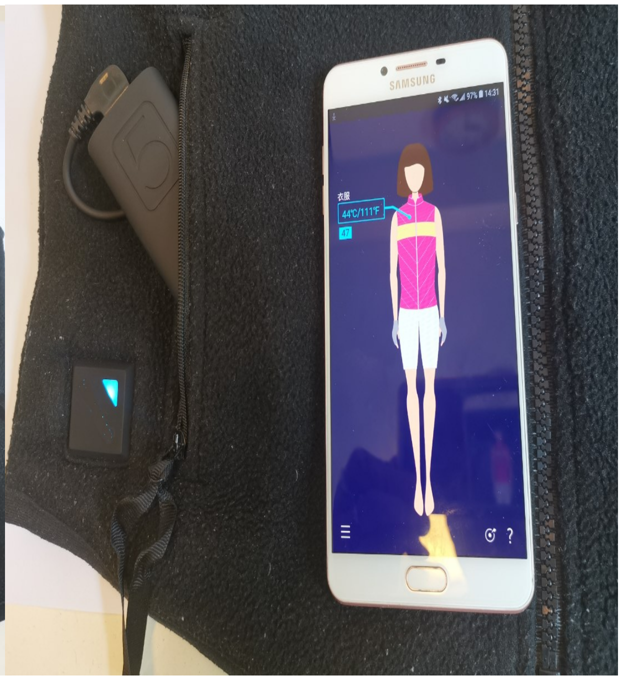


Figure 16. Mobile apps

Figure 17. STEM corner with physical tests set up (textiles and garment products)

In treatment class B, Wool for Sports 2019 with Technology Highlights, physical testing equipment, testing materials like functional wool fabrics, wool garment products and accessories had been arranged and set up by the principal investigator for the workshop. This workshop utilized a PowerPoint presentation concerning the technology highlights, supplementary notes, a project worksheet and wool lab reference swatches which had been tabled inside the workshop (Figure 18-21). The STEM elements involved physical properties and chemical treatment on fabrics and so on. Similar to class A, given a challenging problem concerning SD in FTC industry, trainees started the experiment used the POE learning method to predict, observe, construct own knowledge, explain and propose a new product with application during the STEM activities. A professional observer had also been invited with a priory briefing to jot down the observation and performance of trainees during the workshop. Same as class A, photographic digital images had been taken down for records eventually.

Figure 18. Water repellent test

Figure 19. Wicking test

Figure 20. Water-proof test

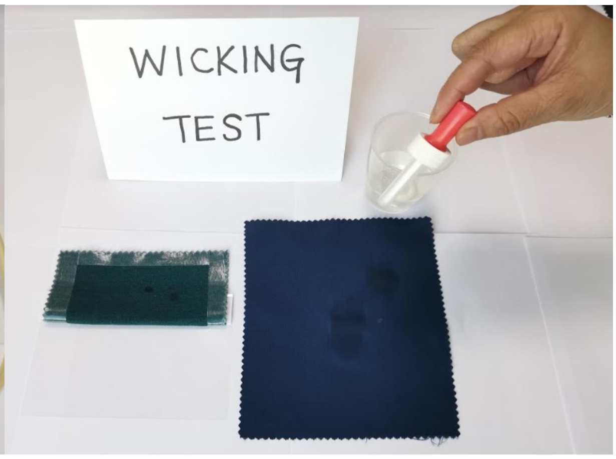


Figure 21. Wicking function demonstration

In treatment class C, CLO 3D Fashion Software CAD Workshop, a meeting was convened with the instructor and discussed about the pedagogy and lesson plan.

A renowned Korean 3D computer software would be the STEM element adopted for the training. Theory part would be delivered first followed by CAD practice (Figure 22 and 23). Trainees had to make use of the CAD skills acquired in the pedagogical portion of the course to reconstruct and draw up a new garment design for presentation. During the presentation, trainees also shared how the CAD skills could help to save up unnecessary sampling process that led to environmental protection as a result. The principal investigator who acted as an observer took records on the lesson on the trainees' performance and interaction with the instructor during the CAD workshop, photographic digital images were shot for future reference.

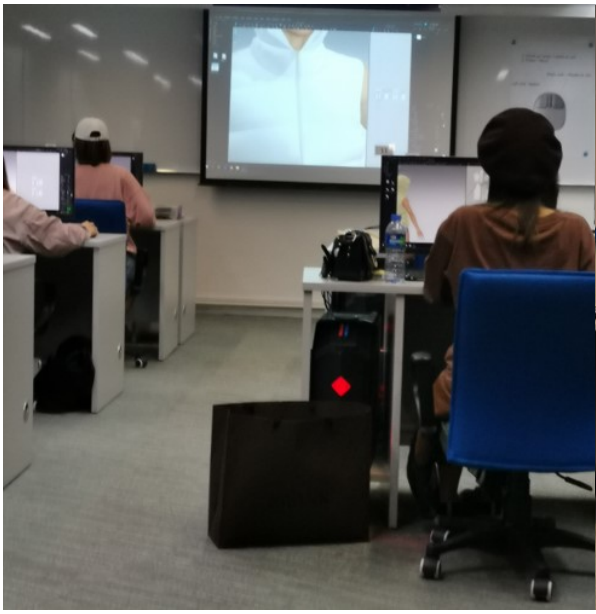


Figure 22. 3D CAD practice Figure 23. 3D CAD workshop

3.16 Operation on Treatment Classes

There were three classes with STEM activities embedded in the workshops have been studied. The first treatment class "CLO 3D Fashion Software CAD Workshop" conducted in the computer workshop in CITA from September to November 2019, in which the instructor who had adopted the pedagogy discussed and recommended by the principal investigator during the workshop delivery. The principal investigator took up the role of a class observer and a questionnaire survey was carried out in the last lesson.

There were altogether 10 lessons in the first treatment class "CLO 3D Fashion Software CAD Workshop". The principal investigator convened a meeting and discussed with the instructor Kay Cheung about the overall pedagogy and schedule for the workshop. The principal investigator who acted as a class observer took records of both the instructor and the trainees' performance during the workshop on 27 November, 2019. Based on the discussion, the instructor first provided the aim of the project, theoretical background, challenging problems (production process and wastes), and general application of fashion brands in the early lessons, followed by computer drawing skills on 3D CAD software and template practice. In the last lesson, which the principal investigator observed, trainees completed their individual project on designing and drawing an outfit, such as a goose down jacket, down vest or casual wear jacket using the 3D CAD software. Instructor and technicians helped those with problems on the computer and answered their queries during the workshop. Finally, the trainees could be able to follow the given templates, guidelines and what had been learned and digested to complete drawing, coloring, patterning with accessories input and visualize them on an avatar for group comments.

The second treatment class was hosted by the principal investigator who served as the instructor throughout the lesson and workshop "Wool for Sports 2019 with Technology Highlights" conducted on 29 November, 2019. Class observation as well as questionnaire survey on trainees have been done thereafter.

In the second treatment class "Wool for Sports 2019 with Technology Highlights" that was conducted on 29 November 2019. The principal investigator who acted as an instructor briefed the class about the nature of this research background and announced the bilingual medium of instruction (Chinese and English) for the delivery. The instructor provided lecture with theory and information on functional wool products through a PowerPoint presentation in the first section, whilst in the second section the instructor demonstrated functional wool textiles and products, and the last section implemented the STEM activities on physical testing on function wool fabrics as well as products. All trainees received an e-project brief via QR codes, the principal instructor announced what problems (environmental issues) were facing now and they formed small groups to work on the physical tests after the lecture and demonstrations. They were required to carry out the experimental exercises on water repellent and wicking properties of wool products; predict, observe and analyze, digest and reconstruct their knowledge and then propose a new application of the materials or products. Finally, the class observation, phone call interview and questionnaire survey had been done for record and further analysis.

The third treatment class “Smart Technologies and Thermal Conductive Textiles” was conducted on 11 January 2020. Again, the principal investigator who also served as an instructor announced the nature of this research background, what were the challenging problems (climate and technology issues), and delivered the theory and informative knowledge through the PowerPoint presentation in the first section in a bilingual medium (Chinese and English). The instructor then demonstrated heat conductive textiles, scarfs and vests in the second section. The final section comprised the STEM activities set for the trainees’ experience. The trainees again received an e-project brief via QR codes and formed small groups. They utilized (VR) headsets and slipped in the mobile phone with an outdoor 360° scenario to simulate a snowy outdoor environment. They had to try on the heat conductive products; to predict, feel, observe and analyze data, construct their knowledge and then propose a new design application thereafter.

By taking the reference and experience from the previous treatment class, the principal investigator/instructor recorded down the good practice and areas of improvement and modified the pedagogy, set up as well as arrangement in the latter class for better achievement. The class observation, phone call interview and questionnaire survey had been conducted on the trainees as well. Appendix I shows the project briefs of STEM activities.

3.17 Observation on Trainees in the STEM Activities

In the first class, “CLO 3D Fashion Software CAD Workshop”, trainees followed the instruction given by the trainer to work on the individual project on designing and drawing the outfit and visualizing them on an avatar for presentation. Trainees were provided with guidance and instruction in computer drawing, color filling, fabric pattern filling, paper patterning as well as accessories like zippers, neck labels and buttons on a coat, suit, vest and down jacket. They showed interest and could apply the learnt skills and complete the STEM activities on an individual project. After their computer practice and thoughtful reflection, the trainees raised some challenges and questions on swimwear and ladies' underwear, for instance, how do someone visualize repeating patterns, lace materials and metal buckles?

In the second class, "Wool for Sports 2019 with Technology Highlights", trainees were split up into three small groups to conduct the STEM activities. In group A, they followed the project brief to examine the wool lab materials, to experience the water repellent and wicking tests and to compare among tests. They discussed, digested and constructed then proposed a creative a 100% wool outdoor ski product. In group B, trainees also carried out the similar testing and comparisons as well as proposed wool blended with Coolmax materials for smart casual wear after they experimented and constructed their knowledge and mindset. Finally, group C performed similar testing and comparisons and proposed active wear such as a yoga outfit with wicking and anti-bacterial properties and odor reduction upon their trial and experimentation.

In the third class, "Smart Technologies and Thermal Conductive Textiles", trainees were divided into three small groups and following the e-project brief for the relevant STEM activities. In group D, they tried on the heat conductive scarf, while groups E and F experienced the VR headset as well as different heat conductive vests. All of them made predictions and observations, analysis, knowledge construction and recommendations during the activities; quite a stark idea from group B that proposed the innovative medical heat conductive products with a healing function, for example, a heated cummerbund for women or heated elbow, knee, and ankle sleeves for elderly people in the community.

Appendix G shows representative digital photographs of STEM activities from the treatment classes.

3.18 Limitations

There were several limitations during the research study. The class size for in-service training course is usually small, around 15 to 20 trainees per class for effective learning and practical works during lesson delivery. Thus, within the three studied classes, there were only 39 trainees who could respond to the questionnaire survey for further analysis. This small batch of respondents might not reflect the actual scenario. In addition, the effects of the COVID-19 pandemic reduced the research timeframe could have limited the result. The principal investigator still has room in the future to extend this study and survey additional in-service training courses and classes to solicit an abundant pool of data for analysis. Another limitation was that this study depended on the instructor's professionalism, specifically his or her industry and teaching experience and knowledge about the content of STEM activities embedded in TVET.

Chapter 4 Data Analysis and Results

4.1 Data Sources and Coding System

The participants included FTC industry representatives and TVET trainers, instructors and trainees, all of whom were selected and recruited from the market and industry who had an interest to participate in the research project. Trainees were recruited through the training organization without any connection with the principal investigator in order to avoid any subjective bias. Coding system was established and implemented in the research study to facilitate the analysis.

4.1.1 Data Sourcing

All the data were coming from the recruited participants in this research project. The principal investigator recruited FTC industry representatives in consideration of coverage in various sectors of the market and industry. The FTC industry representatives come from a design company, a garment enterprise, a vocational institution, an apparel general union and a fashion design management association. The principal investigator believed that these participants would provide their invaluable views and comment on the research topic. The principal investigator knew of the representatives through industry networks and they had an interest in participating in the research project. He also considered the gender of the participants to avoid any bias on the research project.

The principal investigator selected TVET trainers and instructors – who expressed interest in participating – based on vocational training networks. He had no direct working relationship with the participants prior to the research study. They were males and females with significant experience in the FTC industry as well as relevant full-time and part-time teaching experience. Moreover, their specialties cover fashion design and technology, merchandising, fashion textiles, quality assurance and 3D CAD in the fashion industry.

The TVET trainees who expressed an interest in participating were enrolled by the TVET organizations into the training courses embedded with STEM activities. They voluntarily gave their opinions or comments about the STEM workshop. The participants were comprised of male and female, to avoid any gender bias, and the principal investigator had no knowledge about them.

4.1.2 Coding System

To arrange a comprehensive and systematic analysis on qualitative data and protect the interviewees' identities, the principal investigator established a coding system consisting of parent and child codes to identify categories and sub-categories as well as individual interviewees who participated in the research study. The coding system adopted a hierarchical frame to illustrate the vertical and horizontal relationship of all categories and sub-categories under the theme. In view of the ethical issues, the principal investigator also assigned source identity codes to interviewees: FTC_00 to identify industry representatives; TRR_00 to identify trainers and instructors from TVET; and TRE_00 to identify trainees who participated in the STEM workshops. There were altogether 16 interviewees: five FTC representatives (FTC_01 to 05), four trainers and instructors (TRR_01 to 04) and seven trainees (TRE_01 to 07) in the entire research study. The principal investigator also acted as the instructor for the treatment classes and provided observations and comments during the research study.

Furthermore, by creating the parent and child codes in the coding system, the quantification of qualitative results could then enable the principal investigator to compare the quantitative results with the qualitative data respectively.

4.2 Qualitative Data Analysis and Results

All data collected through structured interviews with open-ended questions were grouped and classified into codes, sub-categories, categories and themes for ease of analysis as well as interpretation. Figure 24 shows the hierarchical coding frame that elaborate the relationship among various parent and child codes under the theme "Interrelationship amongst STEM, TVET and Sustainable FTC Industries". Table 4 denotes the meaning for each parent and child code that allowed the data to be sorted comprehensively and analyzed systematically.

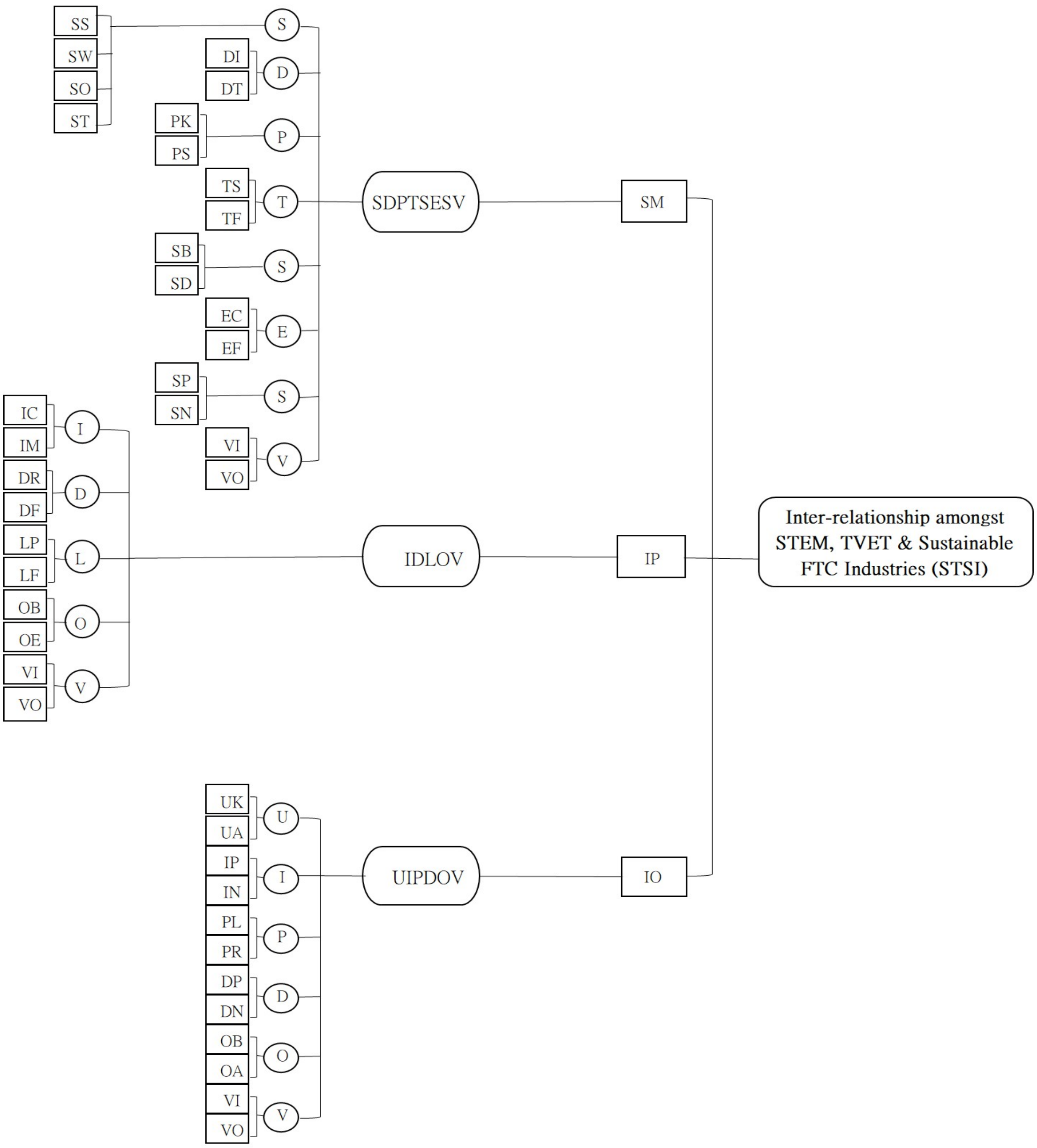


Figure 24. A chart of parent and child codes for analysis

Coding System (Theme / Category / Sub-categories)

Theme	Category	Codes for sub-categories		
Inter-relationship amongst STEM, TVET & Sustainable FTC Industries (STSI)	Subject Matter (SM)	SDPTSESV	SWOT (S)	Strength (SS) Weakness (SW) Opportunities (SO) Threat (ST)
			Demands (D)	Industry Sectors (DI) Technologies (DT)
			Problems (P)	Market Knowhow (PK) Practical Skills (PS)
			TVET Focus (T)	Softwares (TS) Facilities (TF)
			STEM Activities (S)	Benefits (SB) Development (SD)
			Elements & Value in TVET (E)	Skill Content (EC) Feeder to Industries (EF)
			Satisfaction on Skillsets (S)	Positive (SP) Negative (SN)
			Views & Areas of Improvement (V)	Improvement (VI) Others (VO)
	Implementation Process (IP)	IDLOV	Implementation of STEM Activities (I)	Contents (IC) Methods (IM)
			Difficulties & Solutions (D)	Resources (DR) Facilities (DF)
			Learning Attitude of Trainees (L)	Participation (LP) Feedbacks (LF)
			Learning Outcomes (O)	Feedbacks (OF) Effectiveness (OE)
			Views & Areas of Improvement (V)	Improvement (VI) Others (VO)
	Implementation Outcomes (IO)	UIPDOV	Usefulness (U)	Knowledge & Technologies (UK) Application (UA)
			Interest on STEM Activities (I)	Positive Feedbacks (IP) Negative Feedbacks (IN)
			Participation Desire (P)	Like or Dislike (PL) Receptivity (PR)
			Difficulties (D)	Positive Feedbacks (DP) Negative Feedbacks (DN)
			Outcomes & Effectiveness (O)	Expectation before Participation (OB) Expectation after Participation (OA)
			Views & Areas of Improvement (V)	Improvement (VI) Others (VO)

Table 4. The coding system that shows the meanings of the hierarchical and horizontal codes

The purpose of collecting and analyzing qualitative data is to be more informative as well as to understand and explain the results that correlate with the research questions. Therefore, Table 5 presents an explicit mapping table of how the parent and child codes were mapped against the research questions.

Mapping with the Research Questions (RQs)

	STSI																		
	SM								IP					IO					
	S	D	P	T	S	E	S	V	I	D	L	O	V	U	I	P	D	O	V
	SS SW SO ST	DI DT	PK TF	TS TF	SB SD	EC EF	SP SN	VI VO	IC IM	DR DF	LP LF	OF OE	VI VO	UK UA	IP IN	PL PR	DP DN	OB OA	VI VO
RQ1	✓	✓	✓	✓		✓	✓	✓											
RQ2				✓	✓				✓	✓			✓						
RQ3											✓	✓		✓	✓	✓	✓	✓	✓

Table 5. A summary table that shows how parent and child codes were mapped to the research questions.

4.2.1 Analysis and Interpretation from Codes

Each parent codes – subject matter (SM), implementation process (IP) and implementation outcomes (IO) – had several child codes. Each child code carries specific meaning for grouping responses, comments and feedback from the interviewees with assigned respondent identification (RID) numbers, which are further broken down into simple sentences or statement (threads) for ease of coding respectively shown in the tables in Appendix A. The last column of the table depicts the feedback mapping to the research questions and is appended with a '-' indicates a negative response or comment while N/A means the feedbacks was unrelated or not applicable to the research question.

Under the category of **SDPTSESV**, the sub-categories were about the subject matters SWOT, Demands, Problems, TVET Focus, STEM Activities, Elements and Values in TVET, Satisfaction on Skillsets and Views and Areas of Improvement; these further branched into specific codes containing simple statement or threads from the interviewees.

Three out of five FTC representatives (FTCs) reflected that new retail mode, e-commerce with sales and trading strategies as well as English language proficiency were strengths (SS) in HKSAR; however, one FTC worried about the weaknesses (SW) observed from the local textile business. Two FTCs mentioned opportunities (SO): the relocation of the FTC business and higher employability as well as mobility from HKSAR to the Greater Bay Areas in Mainland China. One FTC representative indicated there might also be a threat (ST) in the lack of right people with skillsets in production technology and quality control. The demands (DI) from the FTC industry were training focus in creative marking, e-commerce as well as craft and technical foundation knowledge and skills (reiterated by three FTC representatives). Besides, most FTC representatives claimed to focus more on creative marketing, e-commerce and sales training with foundation knowledge, skills as well as technology backup (DT) such as big data, 3D CAD software and so on. From the FTC representatives' views, the main problems were insufficient technical knowledge and skills (PS) as well as knowledge gaps in market knowhow (PK) among practitioners and markets for problem solving, especially in Mainland China. They agreed that the TVET should focus on training computer-aided design software (TS) CAD and computer-aided manufacture CAM for e-commerce and virtual 3D garments as well as paper pattern design. In addition to the focus on computer software, most of the FTC representatives mentioned that TVET should be supported by training facilities (TF), genuine practice on machinery and work-integrated learning to enrich the learning experience in the curriculum. Only one FTC representative said there were inadequate resource to drive and push STEM elements in TVET.

With regard to the benefit of STEM activities (SB), all FTCs agreed STEM activities embedded in TVET are beneficial to a sustainable industry. In fact, they claimed STEM could act as a tool in teaching methodology to enlighten learning and arouse creativity, which was good in reality so as to benefit the industry.

Apart from the FTCs' comments, trainers or instructors in TVET (TRR) rendered positive comments on STEM activities. They highlighted that trainees could receive actual practice during the workshop, exploring problems and seeking feasible solutions in the entire learning process, an approach that is different from past old-fashioned vocational education.

Three TRRs highlighted that STEM activities were essential and necessary for improving skills and knowledge. Last but not least, one trainee (TRE) supplemented that vivid STEM activities could enrich their learning experience during the workshop practice. In the future development (SD) of STEM activities, besides the support from facilities, all FTCs agreed to explore and incorporate STEM activities to engage trainees in the learning experience so as to keep them up in their lifelong learning pathway from technician to managerial levels.

The elements and values of TVET mentioned by FTCs were about skill content (EC) and feeders (EF) to the industries. Most of the FTCs committed to foundation training in technical knowledge and skills and commented that smart technologies should be provided by local trainers with sufficient STEM knowledge and skills for delivery. However, negative responses were also received from FTCs about the low skill content and knowledge of people from industries. Furthermore, three FTCs mentioned that STEM elements, ethics and compliance are essential in TVET to help environmental sustainability. Almost all the FTCs agreed that TVET could provide feeders to relevant industries and believed that the program made the trainees employable as well as mobilizable which subject to their performance and appraisal. Overall, the FTCs were satisfied with the TVET trainees because they are equipped with skill sets (SP) and competence that somehow fit into the industries. However, three FTCs reiterated not all trainees' skill sets (SN) could be mapped into the industries, including inadequate practical training experience and gaps in science and technology. FTCs' comments on improvement (VI) were to prepare trainees to reach out to more markets and teach them how to learn in the ever-changing market and environment with the incorporation of a work-integrated learning approach. They should be trained to be alert at an early phase and prevent problems from happening instead of solving them once they become apparent.

Other views (VO) from FTCs encompassed how technologies helped in environmental protection, such as virtual 3D simulation in fabric production in order to avoid greenhouse gases emission and waterless textile finishing to avoid toxic waste-water discharge. In addition, the support from industries and the HKSAR government has been vital in the incorporation of training facilities as well as staff development for TVET trainers. The HKSAR government should educate the general public and take a leading role to drive STEM in TVET so as to meet the challenging sustainable industry in the 21st century.

Under the category of **IDLOV**, the sub-categories were about the implementation process –Implementation of STEM activities, Difficulties Encountered and Solutions, Trainees Learning Attitudes and Learning Outcomes and Views and Areas of Improvement. These areas further branched into specific codes containing simple statement or threads from the interviewees concerned.

Regarding the implementation contents (IC), one local FTC industrialist highlighted that the right people, up-to-date facilities, materials and appropriate methodology were important for implementation. One TRR commented that the content could be quite creative by infusing STEM with 3D CAD software, such as virtual design, virtual sewing and virtual fitting. Other

TRRs highlighted that hardware training facilities, equipment, machinery and computer software should be utilized in the implementation method (IM), especially work-integrated learning and collaboration with the FTC industries in order to enhance trainees' authentic workplace learning experience. However, one TRR pointed out that implementation requires demonstration and involves various parties in different roles to effectively teach STEM activities and facilitate learning. Difficulties and limitations in resources (DR) mainly came from management support on manpower and funding. Three TRRs also mentioned the lack of up-to-date training facilities and trainer resources could be drawbacks. Apart from hardware facilities (DF), TRRs also highlighted other concerns: sufficient space, concrete teaching materials and 3D computer software. As such, two TRRs suggested sharing machinery and training facilities across various disciplines or bringing trainees to visit factories, fashion trade fairs and companies so as to complement inadequacies during implementation. With regard to the trainees' learning attitudes in participation (LP), one FTC said most of them accept and appreciate the dynamic approach in STEM activities, and all TRRs reflected that trainees normally demonstrate good participation during workshops. For the feedback in learning attitude (LF), all FTCs and TRRs essentially agreed it was good, positive or satisfactory. Two TRRs reported trainees showed great interest and receptivity towards STEM activities. Only two FTCs highlighted that learning attitude from part-time or in-service trainees seemed even better.

Furthermore, all TRRs indicated that the learning outcomes (OF) demonstrated by the trainees were positive; other TRRs said the outcomes were also fine and constructive. In addition, all TRRs admitted the learning outcomes from trainees were effective (OE), a view that matched with the expectation from the industries.

For the comments on improvement (VI), TRRs reiterated that both theory and STEM activities are vital for all round training, and fashion design students should learn science, chemistry and the nature of materials used for textile production process and should have increased knowledge as well as pay more attention to the needs in contemporary markets. One TRR indicated that STEM activities should be well defined and utilize a PBL approach, which is different from past instructional practice and craft oriented learning. Other views (VO) reflected from TRRs were the importance of multi-disciplinary collaboration, mobile gamification, virtual fashion design competition by using 3D computer software, more hands-on works and synergy with other industries.

The subcategories under **UIPDOV** included implementation outcomes: Usefulness of Knowledge; Technologies and Application; Interest on STEM Activities; Participation Desire; Difficulties, Outcomes and Effectiveness; and Views and Areas of Improvement. These areas further branched into specific codes containing simple statements or threads from the interviewees. All TREs commented that STEM activities are useful (UK) to a certain extent: they allow trainees to see more and understand more and enhances their knowledge as well as learning experience. They claimed STEM activities are helpful in application (UA) and beneficial to their jobs. Moreover, all TREs showed positive interest (IP) during the demonstration and their participation in the STEM activities. There was no negative interest (IN) feedback and collected. Three TREs reflected they loved (PL) STEM activities, which they deemed playful, and felt good during practice with an authentic learning process. However, one TRE said that although the STEM method was good, but it subject to the relevancy between the workshop topic and his or her job (PR). Regarding any difficulty encountered during workshop practice (DN), all TREs reported there were few to none. For the expected learning outcome before participation (OB), two TREs expected to learn more new technologies, whilst two TREs rendered negative views that they did not know it was STEM and did not have much expectation before the workshop commenced. With regard to the learning outcome after participation (OA), all TREs agreed the course was good and professional, and a lot of queries could be resolved through the STEM activities. Most of them would share what they had learnt in the workshop when they were back to their offices. Two TREs said they were satisfied with the workshop, and one TRE reported there was good interaction among trainees. All TREs commented that the STEM workshop was effective and that they learnt some solid new things. For the areas of improvement (VI), TREs suggested having a longer period of STEM activities, conduct the STEM activities in a training center with more advanced facilities, consider more topic areas and prepare more semi-deconstructed samples for demonstration and hands-on practice in order to enrich the learning experience. Finally, the TREs provided other views and comments (VO) such as to visit factories with innovative technologies and organize intermediate courses with STEM activities embedded.

Based on overall views and comments (VO), almost all the FTCs, TRRs and TREs agreed the STEM activities were able to enhance TVET trainees' knowledge and skill competence to meet the challenging sustainable industry in the 21st century.

In summary, there were total 181 applicable responses or threads from all FTCs, TRRs and TREs, with 85 threads were under SDPTSESV, 50 threads were under IDLOV and 46 threads were under UIPDOV. Table 6 shows the number of threads that mapped to each research question respectively.

Appendix F shows the details of qualitative analysis from respondents.

Research questions	Number of mapped threads
RQ1	62 (with 6 negative comments)
RQ2	48 (with 3 negative comments)
RQ3	66 (with 2 negative comments + 1 uncertain view)
	5 N/A (not applicable)

Table 6. The number of responses (threads) mapped to the research questions

4.2.2 Bias and Limitations

The interview protocols for FTC industry representatives, instructors and lecturers as well as trainees from the STEM workshops could indeed help understand the root problems and answers to those research questions. The coverage of interviewees from the FTC industry is sufficient because it embraces the representatives from design management associations, worker unions, employers, enterprises and vocational training universities. The interviewed trainers were full- and part-time instructors as well as lecturers from vocational training institutes. Last but not least, the interviewees from the classes were males and females with an interest in the STEM workshops. However, limited findings from small scale interviews conducted on the above stakeholders might not be able to reflect the true scenario in the research areas. Indeed, a scalable study that can increase the number of interviews and observations should be planned and executed in order to ensure the most representative results for the research project.

In the real world, most evidence and data collected are usually complicated relative to belief and assumptions. Researchers normally search for data that constructively align with their expectation and might interpret those results in a biased manner. As the principal investigator, he has already borne that in mind because this kind of confirmation bias seems to reduce the time and effort required in the research effort. The investigator merely needs to focus and collect data that are positively reflected in the research questions. To be more objective, the principal investigator has to avoid using leading or suggestive protocols and employ open-ended questions by which participants can provide details. Moreover, bias in interpretation of results might happen when an investigator has less of an intention to collect opposing data or alternative information and hence affecting the validity of the whole answer to the research topic. To show these biases have been avoided, the principal investigator utilized reverse questions in the protocols during the interviews and looked for irregularities. Finally, an investigator might underestimate the diversity of data from a qualitative standpoint, such as small sample batch, over highlighting common features and ignoring the minimum difference, or even putting up theories that do not fit well into the data collected (Maxwell, 2011, pp. 64–65).

4.2.3 Conclusion

The interviews produced a myriad of useful information and concrete feedback. In general, almost all the interviewees, regardless of their professional background, provided a positive outlook on STEM activities embedded in TVET and believed it could benefit a sustainable FTC industry in the twenty-first century. In particular, the triangulating interviews from trainees, provided suggestions and inspiring comments for the future analysis and development, besides positive responses from the majority and a few negative responses. These data carve a significant path for an improvement plan and perhaps larger scale qualitative research in the near future.

It is essential to always stay reflective of the research topic and areas, research protocols as well as the entire conceptual framework. Being the principle investigator, it should be more objective and stuck closely to the goals with a crystal clear mindset, looking more deeply at the research methodology and results. Always tried to be aware, open and considerate of alternative or opposing information that might not be in line with my rooted beliefs or expectation. This kind of open-minded reflection might provide new insights or unexpected explanations in a new research area!

4.3 Results on Class/Participant Observations

4.3.1 Facts Gained from Observations

In the research study, the aims and objectives are to investigate the effectiveness of STEM activities embedded in TVET for a sustainable FTC industry. The class and participant observations are required to note the general state of STEM workshop delivery, provide relevant feedbacks to the instructor, identify professional development needs and check the accuracy of teaching practices (CSWEI Teaching Practices Survey, 2013). Upon completion of the interviews with focus groups, the principal investigator utilized the comments and views about technological trends, industry needs, and ways of STEM activity implementation, resources as well as difficulties encountered and so on from industry representatives, trainers and instructors. To develop three treatment classes with STEM activities. The principal investigator identified professional observers with industry and teaching experiences in TVET and invited them to sit in the classes to observe and jot down their comments during class delivery for reference and continuous improvement.

Sawada (2002) claimed that observers must be thoroughly trained to achieve an acceptable interrater reliability; therefore, all observers were briefed and trained on dealing with the class observation exercises, what and how to observe during the lesson delivery and how to record comments in the class observation template. These observation protocols adopted a series of codes to characterize the instructors and trainees how often each behavior and action occurs during the lesson (Hora, Oleson, & Ferrace, 2013; West et al., 2013).

The first class was “CLO 3D Fashion Software CAD Workshop” conducted in CITA. That was a training class using Korean 3D computer software called CLO for virtual garment design as well as 3D virtual fitting on an avatar. The lesson content and pedagogy has been discussed well with the instructor at the beginning of the course.

As a principal investigator, to collect feedback during the lesson by sitting at the rear end of the computer laboratory to observe and record down the class performance in a template as shown in Appendix G, together with the floor plan and photo records. There were no non-Chinese speaking trainees in the workshop, and the medium of instruction was bilingual (Chinese and English). That was a computer laboratory inside the CITA equipped with the instructor and the trainees’ individual computer desktops, projector, screen and the public announcement system. The whole period of the observation was about an hour with the main focus put in the pedagogy and interactive learning laboratory environment. Those trainees were comprised of men and ladies who were practicing on the computer software that was led by the instructor together with the technician along with the practice and delivery. During the on-site observation, the instructor has fully demonstrated the good command and knowledge of subject matter, demonstrating, teaching and coaching the trainees step by step with the assistance from the technician on using the 3D software to draw, construct and design garment details like zippers, color fill, pattern fill and present the final garment product such as goose down jacket or vest on an avatar in a cat-walk runway. All the trainees could make use of the knowledge and skill learnt through the course and apply it in their final garment design and virtual fitting on an avatar which could be used in the next step for a subsequent virtual fashion design competition. During the lesson delivery, instructor had been observed to interact with trainees frequently by posting up questions, engaging and interacting with trainees frequently. While the trainees were very often showed interest to learn and practice the computer software. Besides concentration, trainees often asked questions and interacted with the instructor, the technician and other trainees. They were often motivated and successfully completed the STEM activities set in the lesson. However, when the principal investigator had a causal chat with a trainee after the lesson, the trainee reflected that although she was motivated and engaged during the lesson, she still wondered how useful and applicable the 3D CAD software was across all the fashion lifestyle products in the contemporary market and industry!

In the second class delivery, which was ‘Wool for Sport 2019 with Technology Highlights’ conducted in the resource center of TWC. The resource center consisted of a lecturing area and a workshop area with wool fabrics, products and materials for reference. The principal investigator acted as the chief instructor who delivered the training with Mr. Daniel Chan acted as the observer in that class. He is the manager in charge at the TWC and possessed profound industry knowledge and part-time teaching experience in in-service courses. Prior to the class, both Daniel and the principal investigator were engaged in a 45-minute briefing and training session on how to conduct and record the class observation (see the template in Appendix G, together with the floor plan and photo records for reference and analysis). There was one non-Chinese speaking trainee in the workshop. The instructor discussed this issue with her and committed to use both Chinese and English in the delivery. The PowerPoint presentation, supplementary materials and project brief were also bilingual (Chinese and English). The report reflected that the instructor prepared good training materials and adequately realized the in-service trainees’ needs. The observation noted that the instructor had fully discharged good knowledge about subject matter, demonstration, effectively led STEM activities and posed questions and interacted with the trainees. The trainees often showed interest in learning and participating in the STEM activities set up in the lesson. Moreover, trainees very often asked questions during the lesson to ensure they understood the material and successfully completed the STEM activities with good interaction among themselves and myself. Finally, most of the trainees expressed that the workshop content was useful and practical for their daily jobs. Although the majority of the trainees were engaged during the workshop, the instructor observed that there were some laid back trainees just walking around and chatting without practicing any STEM activities during the lesson.

The principal investigator who acted as instructor to conduct the third class, 'Smart Technologies and Thermal Conductive Textiles, in a multi-functional room at the HKWAIU; it contained a computer, a projector, a screen and a public announcement system. Ms Mandy Fung, the chairperson of the HKWAIU, acted as the observer in that class. She has profound industry and part-time teaching experience in in-service courses. All trainees in the workshop spoke Chinese, and instructor delivered the instruction in Chinese and English. Mandy and the instructor had a 45-minute briefing and training conversation on how to conduct and record class observations (see the template in Appendix G, together with the floor plan photos as well as photo records for reference and analysis). The report reflected that the instructor fully discharged good knowledge about the subject matter, provided good demonstration and teaching materials, effectively led STEM activities and frequently posed questions to and interacted with trainees. The trainees often showed interest in listening and learning and actively participated in the STEM activities set up in the lesson as well as discussion. Moreover, trainees often asked questions during the lesson to increase their understanding. They were highly motivated and successfully completed the STEM activities with good interaction among themselves and the instructor. Most of the trainees reported that the activities could increase and enrich their learning experience on design knowledge as well as application which echoed what Liu and Hsiao (2002) finding in their research study. However, there were a few trainees who did not participate in the STEM activities at all.

4.3.2 What New Questions Arose during/after the Observation

In the first class, the CAD workshop, the principal investigator observed the trainees were highly concentrated while practicing with the software. Two trainees left almost at the end of the lesson, but the principal investigator chatted with a few trainees who stayed behind. The principal investigator discovered that while they bought into the concept and general application of CAD software, they questioned whether that software could work on all types of fashion garments, including knitwear and underwear items.

In the second class concerning functional wool textile and products, the principal investigator who acted as instructor observed the trainees paid attention to the lecture and demonstration. To the surprise, some trainees had a keen interest in testing the wool fabrics and garments with the apparatus and had many questions. The instructor distributed a project brief to the trainees and guided them for two physical tests on wool fabrics and products. They had to follow the testing procedures, predict what would happen, jot down their observations, analyses, discuss, construct knowledge and eventually propose a new application in product design. One trainee provided a novel idea: blend functional wool with synthetic fiber such as the Coolmax polyester. Coolmax polyester itself possesses good wicking function, and combining it with wool fabric might enhance the wicking function of wool (merino wool) products, which are more suitable for outdoor garments. This combination would result in a win–win situation. In theory, it married natural wool with synthetic polyester, an application that could shift wool from an urban and dressy outfit into a sporty functional outdoor outfit, an idea that sounded really innovative!

In the third class concerning heat conductive technology in textile and garment products, principal investigator being the instructor of the class noticed the trainees were fully engaged in the activities during the workshop. Also, the instructor distributed a project brief to the trainees and guided them to apply the POE approach to evaluate the effect on heat conductive products with temperature controlled by mobile apps. They greatly appreciated trying on and testing those heat conductive products (vests and scarf) under the simulated snowy environment by using the VR technology and the VR headset. They raised many questions at the end of the lesson, including one good recommendation for a new product that applies heat conductive technology for elderly and medical purposes. It was quite fresh and alerted the instructor to other aspects of applications. Besides the normal function for body warming in a coldly outdoor occasion, it could be further designed and modified for medical purposes: heat therapy for elderly people on the neck, elbows and knees, an approach that could alleviate pain during winter. Furthermore, it could also be applied as a medical apparatus for necessary treatment of abdominal pain and uterus warming for women. These are new areas or questions to further explore on the heat conductive technology!

4.3.3 Research Study Modifications Based on the Research Area

Regarding the research topic 'Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry', the observations from the three treatment classes allowed the principal investigator to consider the effectiveness on implementing STEM activities. For instance, within the STEM activities in heat conductive textiles and products, an instructor could prepare more exercise and practice on constructing and assembling heat-conductive products from intermediate parts in order to have more explicit pictures of how the mechanism runs. The principal investigator wondered whether the 'Wool for Sport' course should be taught inside a chemical laboratory to allow trainees to deconstruct a garment, untwist the yarns and place them under a microscope to view the cross-section, plying, structure and characteristics. This approach could enhance trainees' understanding and learning experience in a greater depth. Nothing specially observed in the 3D CAD workshop.

Based on the above observations, there was no need to modify the research study because it mainly concerned the details of the activities rather than the aim and objectives of the research. However, these observations have provided the principal investigator with insights on the context details and development of STEM activities for later on continuous improvement.

4.3.4 Questions from the Observation Experience

After completion of the courses and STEM workshops, questions arose from the class observations that reflected the application of each technology the trainees learnt. For example, although 3D CAD software is a powerful tool for virtual design and visualization of the final effect prior to the actual garment sample being produced, how applicable is it to all types of woven and knitted garments, including intimate wear and underwear?

Functional Sportwool seems to be a potential breakthrough technology relative to traditional wool products, but what about blending or combining natural wool fibers with synthetic polyester fibers to enhance the wicking and quick dry function in an outdoor garment?

Finally, could heat-conductive technology be applied in medical or health of body care sectors instead of warm keeping function in the garment field?

Those were good questions from observation experience that would be useful to investigate in the next step of the research study.

4.3.5 Limitations

There were only three classes conducted during the research period; thus, the findings are not substantial enough to evaluate and modify the research study. Moreover, the observations were quite dependent on personal dependent observations, and thus there might be some bias during observation and interpretation during the entire process.

4.3.6 Conclusion

The class observations provided some inspiration and insights for my research study, but there was a limited number of classes observed and some potential personal bias. Henceforth, it might be better to arrange more consecutive class observations in larger and uniform class sizes so as to collect more data as well as information for analysis and interpretation, all of which could enhance the qualitative research area. Last but not least, as a researcher and principal investigator, it should always remained open minded to avoid applying any generalizations or confirmation biases during the exercise in the research area, and different observers might have different meanings and interpretations in the participant or class observation as well.

4.4 Quantitative Analysis of the STEM Activity Programs in TVET

There were three treatment classes in the research study:

Class A: Smart Technologies and Thermal Conductive Textiles

(STEM activity: thermal conductive engineering basis, N=15)

There were 17 trainees enrolled, 15 valid questionnaires returned.

Class B: Wool for Sports 2019 with Technology Highlights

(STEM activity: chemical science and technology basis, N=16)

There were 16 trainees enrolled, 16 valid questionnaires returned.

Class C: CLO 3D Fashion Software CAD Workshop

(STEM activity: CAD science and technology basis, N=8)

There were 12 enrolled, 8 valid questionnaires returned.

4.4.1 Developing STEM Evaluation Scale (SES)

As the SES in relation to TVET has not been addressed much from the literature review, therefore, the principal investigator developed them based on the research questions, input from TVET trainers, pilot study as well as consultation from an FTC industry representative who was also a TVET instructor for the evaluation process to ensure the validity.

Base on the rationale from research objective and context of research questions, the SES could be grouped into attitudes about two main domains named ‘Practicability’ and ‘Content’ respectively.

To evaluate the STEM activity program, it is suggested including two domain, practicability and content.

First domain: practicability

Practicability stands for how practicable and helpfulness of STEM activities in the program is. The higher the score, the more the respondent think the program is practicable.

Second domain: content

One of the direct ways to evaluate a STEM activity program is to study how useful the content it is. The higher the score, the more the respondent think the program content is useful.

4.4.2 Survey Design

As there are no evaluation scale of STEM was found in TVET this moment. The items are created by the author base on the interviews with target participants. In total, 9 items were created. 5 items are designed for the first domain, “practicability”, while 4 items are designed for the second domain “content”.

Items are rated on a 5-point Likert scale ranging from 1 (*strongly disagree*), 2 (*disagree*), 3 (*neutral*), 4 (*agree*), 5 (*strongly agree*). Two items in “Content” are reversed items in order to minimize the response bias (Suárez-Alvarez et al., 2018). The description of the items is shown below.

Table 7. STEM evaluation scale (SES)

1.	I will recommend my friends or colleagues to enrol in STEM-based training course.
2.	STEM activities are not useful and applicable to my daily life or existing job. *
3.	STEM activities can motivate and enhance my learning outcomes in the course.
4.	STEM activities are complicated and difficult to master *
5.	Overall speaking, STEM activities can enhance TVET for practitioners from the Fashion Textile and Clothing industry.
6.	I like the content and STEM activities in this course.
7.	I enjoy taking the course with STEM activities embedded.
8.	I understand the course content and STEM after completion of this course.
9.	STEM activities in this course help me understand the knowledge and master the skill sets effectively.

* Reverse scored.

Table 8. The domain of the STEM Evaluation Scale

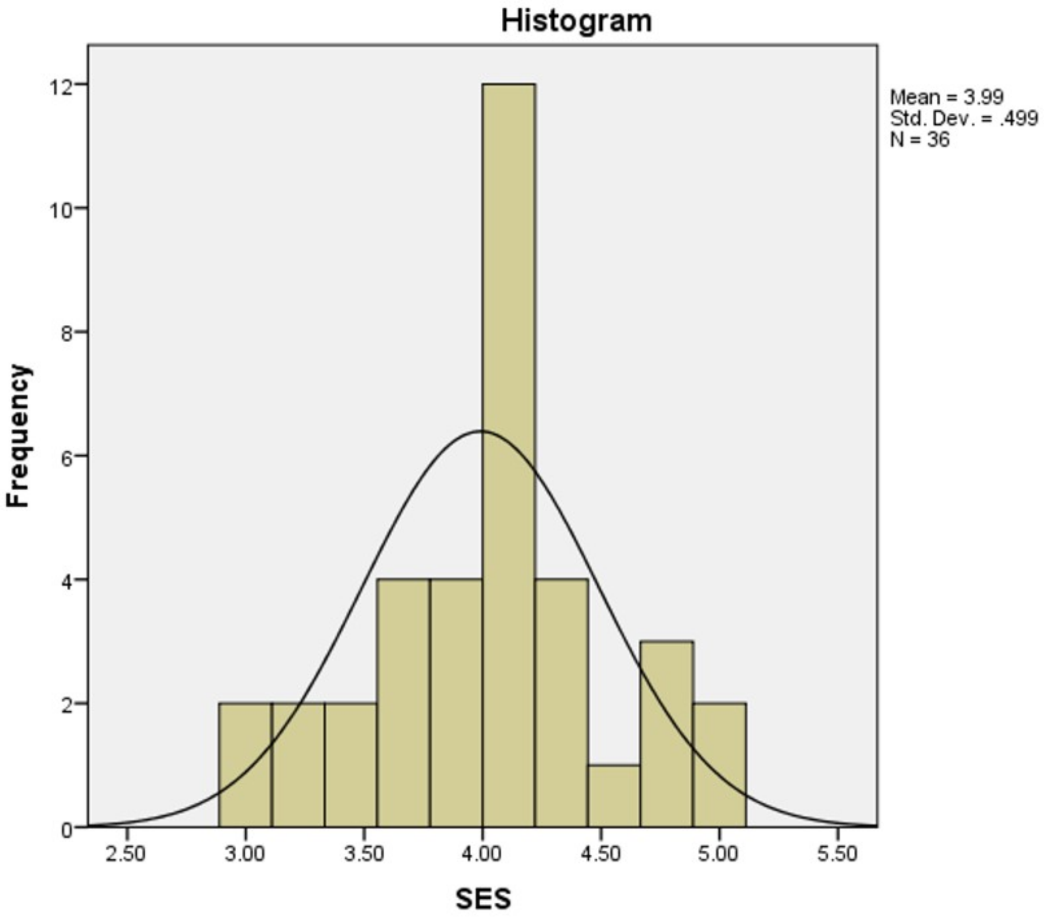
Item	Domain	Scoring
1, 3, 5, 7, 9	Practicability	1 to 5
2*, 4 *, 6, 8	Content	1 to 5

* Reverse scored.

4.4.3 Study Sample

The scale is examined by 3 class of students. In total, the sample is 39. 15 students were invited in the first class, class A. 16 students were invited in the second class, class B while 8 students were invited in the third class, class C. Each class carried different STEM activity program. Class A implemented the STEM activity program of thermal conductive engineering technology basis, Class B implemented the STEM activity program of chemical science and technology basis, while Class C was CAD science and technology basis. 9 of the sample was male while 30 were female. The distribution of age was biased to middle-aged, which was seems inevitable due to the students were mainly experienced employees enrolled who have interest in those workshops. 23.7% respondent were aged 21-30, 28.9% were aged 31-40 and 47.4% were aged above 41. Moreover, for the job status, 92.3% of the respondents were full time worker, 2.6% were part time worker while 5.1% were in other condition.

The histogram of overall STEM Evaluation Scale (SES) scores for all respondents is shown below (Figure 25)



4.4.4 Results

a. Validity

To examine the validity, exploratory factor analysis (EFA) is used. It is used to explore the pattern of the variables and the respondents (Child, 2006; Yong & Pearce, 2013). The reason why EFA is used is because it is the first step of forming scales (Yong & Pearce, 2013). It is nearly a common knowledge of exploratory factor analysis required a relatively large sample size, i.e. minimum 50 samples while a thousand is much preferable. However, de Winter, Dodou and Wieringa (2009) suggested that if the data are well conditioned, i.e. high level of loadings, low number of factors and high numbers of variables, EFA is still reliable for a below 50-case study.

a1. Kaiser-Meyer-Olkin & anti-image correlation result

The Kaiser Meyer Olkin (KMO) value which sampling adequacy is 0.81. The Bartlett's test of sphericity x^2 (*df*, *N*=36) = 141.58, $p < 0.001$. These results showed that the data were good for EFA and the items are related. As a results, it is possible to generate distinct and reliable factors (Yong & Pearce, 2013).

a2. Total variance explained result

The total variance is used to determine the number of distinct and reliable factors. In this study, the cumulative variance of 63.52% indicated that there should be two reliable factors.

a3. Rotated component Matrix

The table below showed the rotated matrix and how the items were formed to 2 components. The factor loading is shown for the minimum of 0.4.

Table 9. Factor loading of rotated matrix for the SES

Item	Practicability	Content
Item 1. I will recommend my friends or colleagues to enroll in STEM-based training course.	0.866	
Item 3. STEM activities can motivate and enhance my learning outcomes in the course.	0.745	0.446
Item 5. Overall speaking, STEM activities can enhance TVET for practitioners from the Fashion Textile and Clothing industry.	0.740	
Item 7. I enjoy taking the course with STEM activities embedded.	0.738	
Item 9. STEM activities in this course help me understand the knowledge and master the skill sets effectively.	0.671	0.487
Item 2. STEM activities are not useful and applicable to my daily life or existing job. (reverse scored)		0.786

Item 4. STEM activities are complicated and difficult to master. (reverse scored)		0.661
Item 6. I like the content & STEM activities in this course.	0.566	0.620
Item 8. I understand the course content & STEM after completion of this course.	0.437	0.591
Eigenvalues	4.39	1.32
% of variance	48.81	14.71

b. Reliability

Reliability test is used to examine if the Cronbach's alpha is acceptable. If the loading of Cronbach's alpha is good, it means the scale has higher internal consistency, in other words, a higher reliability.

SES appears to be reliable, (α =0.84). Only one item appeared to be worthy of retention, but after deleting the item, α could only increase to 0.86. Therefore, no items were deleted in this scale.

c. Overall Scoring of SES

With the maximum scoring of 5, the average score of SES is satisfied (M = 3.99, SD = 0.500). Both components gained a high score which is around 4, out of 5. It showed that respondents recognized the practicability and the usefulness of the STEM activity program. The table is shown below.

Table 10. Overall STEM Evaluation Scale (SES) scores

	Mean	Standard Deviation
SES	3.99	0.500
SES_Practicability	4.04	0.535
SES_Content	3.91	0.584

The result above indicates that in general, respondents are satisfied with the STEM activity program. With the maximum score of 5, the average score of 4 shows that they are both satisfied with the STEM activity program, in terms of the content and practicability.

Bivariate correlation is used to explore the relation between the items. From the table below, almost all items are inter-correlated. They have a strong correlation, i.e. $r = 0.4$ to 0.6. Item 2 is only correlated to item 4, which may be a clue that they belong to a same component.

Table 11. Correlation between STEM Evaluation Scale (SES) items

	Item 1	Item 2^	Item 3	Item 4^	Item 5	Item 6	Item 7	Item 8
Item 1	--							
Item 2 ^	-0.06	--						
Item 3	0.65**	0.22	--					
Item 4 ^	0.30	0.35*	0.47**	--				
Item 5	0.57**	0.05	0.62**	0.27	--			
Item 6	0.52**	0.20	0.60**	0.42*	0.38*	--		
Item 7	0.49**	-0.00	0.52**	0.14	0.46**	0.38*	--	
Item 8	0.50**	0.26	0.52**	0.21	0.26	0.62**	0.20	--
Item 9	0.69**	0.14	0.63**	0.34*	0.38*	0.70**	0.36*	0.60**

* $p < 0.05$, ** $p < 0.01$.

^ reversed items.

d. Group Differences on SES

The scale is tested to examine if background biased occur. Gender, age, job status and program activities differences will be examined.

d1. Gender differences

Independent sample T-test is used to examine any difference between genders. From the table below, there was no significant difference in the score for male (M=4.09, SD=0.37) and female (M=3.96, SD=0.53); $t(34)=-0.68$, $p = 0.50$. Hence, there are no gender differences for the scale.

Table 12. Gender differences on SES

	Male		Female		
	M	SD	M	SD	*t*-test
SES	4.09 (N=8)	0.37	3.96 (N=28)	0.53	0.68
SES_Practicability	4.07 (N=9)	0.48	4.03 (N=29)	0.56	0.16
SES_Content	4.13 (N=8)	0.42	3.85 (N=29)	0.61	1.17

* $p < 0.05$, ** $p < 0.01$.

d2. Age differences

One-way ANOVA is used to examine the effect of age group on SES. In general, the effect of age group on SES was significant, F (2,33) = 9.01, p = 0.001. Post-hoc analysis using Turkey HSD test showed that there are no significantly differences between aged 21-30 (*M* = 3.54 , *SD* = 0.33) and aged 31-40 (*M* = 0.39 , *SD* = 0.51), aged 31-40 (*M* = 0.39 , *SD* = 0.51) and aged above 41 (*M* = 4.26 , *SD* = 0.40). Meanwhile, there is a significant difference between aged 21-30 (*M* = 3.54 , *SD* = 0.33) and aged above 41 (*M* = 4.26 , *SD* = 0.40). However, both the youngest and oldest age group SES score were tended to positive, which means they were satisfied with the STEM activity program.

Table 13. One-way ANOVA

	df	F	*p*
Age group	2	9.01	0.001
N=36			

* $p < 0.05$, ** $p < 0.01$.

d3. Job status differences

Due to the limitation of the sample size, the job status is regrouped into 2 groups. Hence, independent sample T-test is used. Full time worker and the others. From the table below, there was no significant differences in the score for full time worker (*M*=3.99, *SD*=0.51) and others (*M*=4.06, *SD*=0.24); $t(34)=-0.19$, $p = 0.50$. Hence, there are no job status differences for the scale.

Table 14. Job Status differences on SES

	Full time worker		Others		
	M	SD	M	SD	*t*-test
SES	3.99 (N=34)	0.51	4.06 (N=2)	0.24	-0.19
SES_Practicability	4.03 (N=36)	0.55	4.20 (N=2)	0.28	-0.42
SES_Content	3.92 (N=34)	0.61	3.83 (N=3)	0.14	0.24

* $p < 0.05$, ** $p < 0.01$.

d4. STEM activity program differences

Different class was implemented different STEM activity program, hence One-way ANOVA is used to explore if there is a difference on SES scoring for different STEM program. In general, the effect of class on SES was significant, ($F(2,33) = 9.25$, $p = 0.001$). Post-hoc analysis using Turkey HSD test showed that there are significantly difference between Class A ($M = 4.32$, $SD = 0.49$) and Class B ($M = 3.90$, $SD = 0.26$), Class A ($M = 4.32$, $SD = 0.49$) and Class C ($M = 3.52$, $SD = 0.51$). Meanwhile, there is no significant difference Class B ($M = 3.90$, $SD = 0.26$) and C ($M = 3.52$, $SD = 0.51$). Hence, different program may affect the scoring of SES. However, on average, the respondents in three classes had a good score on SES. On the other hand, further studies may be needed to examine the STEM activity program differences due to the sharp difference on sample size of class A (*N*=14), B (*N*=15) and C (*N*=7), content of interest and ease of equipment usage.

Table 15. One-way ANOVA

	df	F	*p*
Class	2	9.25	0.001**
N=35			

* $p < 0.05$, ** $p < 0.01$.

Appendix H shows the raw data from SPSS analysis.

4.5 Concluding Remarks

Biases and limitations might exist due to personal reasons, sample sizes, design settings, protocols, facilities, demonstrations, delivery, coaching and research methods. Hence, it is essential to stay reflective of the research areas and questions, to be open minded and objective. An investigator should pay attention to the research process and results and remain aware and consider any alternative or opposing information that might not be in line with his or her rooted belief or expectation.

4.5.1 Face-to-face Interviews

The face-to-face interviews adopted structural protocols with open-ended questions to collect in-depth views and comments from the participants. Bias still has a chance to exist, depending on how the questions are asked or if the interviewer gives hints and suggests answers. There might be a limitation in the coverage and validity of the protocols as well as the reliability of what the participants responded in return.

4.5.2 Classroom Observation

Given that there were only three classroom observations, there might be a limitation due to subjective views, confirmation bias or generalization from the observers. Although all the observers (including the principal investigator for the CAD class) are professionals and have good experience in vocational education and training, it is still better to openly recruit professional observers from the industry to carry out the task to eliminate any bias or known relationship with trainers who will deliver the lesson.

4.5.3 Questionnaire Survey

There might be a limitation from the uneven and small class size of the three treatment classes, which were subject to an open and random enrolment. Apart from class size, there was also a gender difference recorded in the survey study due to open enrolment from the market. In future research, more classes embedded with various kind of STEM activities should be investigated to avoid bias and generalization.

Chapter 5 Discussion

Base on the results from data analysis on qualitative and quantitative researches in previous chapters, the following are the discussion in responding to the research questions in the research study.

5.1 Author's Role in the Research Study

The author who is also the principal investigator in the research study of "Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry". The principal investigator has planned this project as an action research approach. Action research (AR) is a general descriptive term that covers different forms of action-oriented research, which indicates diversity in theory and practice among researchers so as to provide them with a wide range of choice on what might be suitable for research questions (Reason & Bradbury, 2001). Moreover, one of the major characteristics of action research is that it may encompass various types of data collection methods via qualitative and quantitative tools such as interviews and surveys (Gummesson, 2000). Henceforth, AR could enable the principal investigator to study the process during in person participation, from research design, setting, preparation, organization, observations, field notes, analysis, self-reflection, conducting a questionnaire survey and forming conclusions to arrive at improvement actions.

The principal investigator is a professional from the FTC industry who has over 20 years of experience in design, merchandising, production and quality assurance. In addition, he has over 25 years of part-time and full-time vocational training in fashion textile and clothing design, vocational programs and in-service course development and delivery. The research design utilized the quantitative research method to triangulate with the qualitative findings to interrogate the relationship and effect of STEM activities embedded in TVET to ensure a sustainable FTC industry. In brief, his roles in this study have been principal investigator, observer, instructor, design planner and setter, organizer as well as interviewer. The principal investigator has also written this thesis.

5.2 Qualitative Data Interpretation

The principal investigator used the insights drawn from qualitative data to respond to the research questions. This analysis is presented separately for each research question.

5.2.1 What are the perspectives of FTC industry representatives on TVET for in-service practitioners in HKSAR? (RQ1)

FTC businesses have been almost entirely relocated from HKSAR to Mainland China, especially around the Greater Bay Area, in recent decades. The industry has shifted from labor intensive to a trading and the new retailing mode. The focus remains on the design and merchandising sectors instead of the textile sector. There is still a lack of people with the right skill sets in the industry; hence, TVET should provide fundamental skills and knowledge or even upskilling in order to cover effectively the aforementioned sectors. The principal investigator agrees with the FTC industry representatives that more TVET graduates are entering the retail sector. Contemporary TVET serves to train people to be aware and prevent problems from happening rather than rectifying a problem after it occurs. Therefore, trainees in TVET should be equipped with a good technical knowledge foundation. It is true that TVET has been emphasized to a greater extent in past years compared with the present, as mentioned by the FTC industry representatives. However, under the government's new Technology Talent Scheme – with the support of the FTC industry on the Reindustrialization and Technology Training Program (RTTP), which recently launched – TVET concerning re-skilling and upskilling seems to have been revitalized. This change can definitely help ensure the sustainability of the FTC industry.

However, the principal investigator hesitates to agree with FTC representatives that TVET has become weak owing to less support from the HKSAR government. The government has already allocated funding for a wide spectrum of STEM education and training development, including but not limited to training resources and facilities as well as trainer development. For instance, there are STEM centers set up under the VTC in HKSAR. They are providing internal training and also opening to the public. In-service practitioners can make use of them for their lifelong learning activities. To summarize FTC representatives' perspectives on TVET for in-service practitioners, current training should highlight e-commerce, information and communications technology (ICT) such as 3D CAD on garment product design to enhance the design abilities of designers and in-service practitioners and technical knowledge and skillsets for the benefit of the industry. Overall, TVET should be more sensitive and adaptive to the market changes as well as the needs from the trainees and in-service practitioners.

5.2.1.1 What are the current and future needs for the quality/ capacity of manpower?

Under Industry 4.0 in which focusing on the cyber physical system, Internet of Things, networks and media platforms, the future needs seem to be more focused on e-commerce, marketing and online sales-related sectors. Other sectors like design, product development and merchandising are still needed to have certain backup with current technologies, such as big data for marketing and new retailing that embraces online sales platform in addition to physical stores, virtual design businesses, virtual fitting and mobile apps on personalized products. In the 21st century, the HKSAR's role has become more competitive in exchanging data as well as strong in the design process to approach international markets. The principal investigator concurs with the FTC representatives that manpower strength should emphasize creative sales and marketing, but we cannot miss out the element of technology because craft and technical skills are the foundation of capacity in manpower development.

Therefore, the future needs for the quality/capacity of manpower are technologists or technicians with strong technological background with multi-talents and managerial capabilities to fit in the ever-demanding industry, especially for the sales and marketing sectors.

5.2.1.2 What are the main problems or deficiencies of the current in-service practitioners?

Having been in FTC design and manufacturing for many years, the principal investigator agrees with the FTC representatives that practitioners are lacking in technical knowledge background as well as problem solving skills in product design and production. However, the principal investigator thinks training on machinery and software practice is not enough. It is important to train practitioners so that they learn how to deal with and solve unpredictable problems that happen daily. Therefore, the main deficiency is inadequate technical knowledge and skill sets to forecast and tackle an authentic problem, together with the strategy required to prevent problems and solve them in their workplace.

5.2.2 What about STEM and how to implement STEM activities to enhance TVET in a sustainable FTC industry? (RQ2)

Most of the stakeholders in the FTC industry knew about STEM during the focus group interviews. They knew STEM relates largely to science and technology, mathematics, and they knew somewhat about big data. Some of the examples they cited were 3D garment pattern and virtual fitting, virtual project display as well as presentation. Regarding the implementation measures, an industrialist in HKSAR provided holistic views like 人 (an instructor who knows how to teach), 機 (machinery and facilities), 物 (enough material for practice) and 法 (methodology in delivery). Machinery and facilities and methodology in delivery also involve STEM elements. The principal investigator believes that work-integrated learning (WIL) in collaboration with the FTC industry would enable authentic workplace learning experience for TVET trainees. It coincides with the view from some instructors that new things are developing fast in the industry and are not being reflected in TVET. One participant mentioned a VR project within the industry that has provided good implementation results because trainees can visit the virtual cotton organic farm in northwest China (in 新疆) and experience the entire manufacturing process from cotton harvest, yarn spinning, dyeing, finishing and fabric weaving to the final garment production in one go through the VR experience. The principal investigator agrees that this is a practical and fruitful STEM activity implementation that effectively considers time, venue, cost and safety issues. Another way of implementation highlighted by the trainers is the application of ICT, such as virtual design, virtual paper pattern manipulation, virtual sewing and virtual garment fitting on an avatar. These methods seem to represent a prevalent trend to save from exploiting unnecessary resources. So, by using technologies such as ICT with computer facilities in STEM training, it can efficiently enhance TVET in a sustainable FTC industry.

5.2.2.1 What are the main difficulties or constraints for the practical workshop implementation?

Based on the information collected from trainers and instructors, top management support, extra manpower, funding and facility resources as well as interdisciplinary coordination are the main difficulties and constraints that come across. The principal investigator agrees with the participants with regard to the ways to overcome those limitations: secure support from top management with adequate resources on funding and facilities. AIP Conference Proceedings 1887, 020076 (2017) also reflected that strong commitment and support from top management and stakeholders were required to drive and enhance TVET. It is also good practice for in-service practitioners to share any new ideas during TVET in order to overcome shortages in facilities during training.

5.2.2.2 What are the resources of facilities for full implementation?

Most participants agreed it is necessary to incorporate new machinery, computer facilities, concrete teaching materials, funding, sponsorship and manpower for full implementation of STEM activities in training. For instance, from the literature review about the project on the changing role of teachers for enhancing development in the teaching profession in the learning center scheme, the findings suggest that support from the funding allocation, school administration and so on were essential for the final success (Cheng & Yeung, 2008). Moreover, the principal investigator agrees with one full-time TVET instructor who suggested sharing all machinery, up-to-date facilities and training venue across various disciplines so as to solve the limitations in space and locations. This eventuality might also optimize the manpower resources in the delivery too. The principal investigator noticed that many representatives mentioned the importance of computer facilities in STEM training: they enable trainees to explore, try, experience, observe, analyze, construct knowledge and propose new applications in design at the end of the activity. These activities indeed enhance their authentic learning experience in VR in the era of digitalization rather than just viewing the PowerPoint presentations that an instructor might deliver with a boring or disinterested tone. Henceforth, besides new machineries, concrete teaching materials and funding, computer facilities seemed to be the most concern for full implementation.

5.2.3 Is there any effectiveness in teaching and learning upon STEM activities infused in TVET? (RQ3)

All the FTC industry representatives, trainers and instructors basically agreed that

STEM activities embedded in TVET are effective and can somehow benefit the industry. This training is effective for trainees to acquire up-to-date knowledge during a practical workshop, an endeavor that can strengthen up their confidence together with the hands-on skill sets that map in the industry's expectation.

The principal investigator adopted triangulation methods to investigate whether what the FTC industry representatives and TVET trainers mentioned are true. Those methods encompass the class and participant observations as well as the post-interviews with trainee representatives from the treatment classes embedded with STEM activities. Based on observations of the participants in the treatment classes, trainees are often to very often being motivated to participate in those STEM activities; they can also complete them within the workshops. Furthermore, they can follow the content and instruction stipulated in the STEM project brief to predict, observe, analyze, discuss, construct knowledge and propose a new application or design in the products for the market that meets the intended learning outcome of the STEM activities infused in those workshops. Those trainees agreed that the STEM activities are effective during practice and experience in real products and also raise that it can help them in functional knowledge as well as enhancing their understanding and application in their jobs, in particular for proposing new product development proposals to their customers as well. However, as the principal investigator as well as the instructor for two treatment classes, the principal investigator noticed that there were a few trainees who were reluctant to participate in the STEM activities for unknown reasons. The principal investigator wonders whether the types of STEM activity matter: are they boring or not helpful to them in their jobs? Further, were there problems during the lesson delivery, guidance or demonstration process? Answering these questions requires further investigation in a research. Overall, almost all parties agreed the effectiveness of STEM activities infused in TVET training courses.

5.2.3.1 What are the industry representatives', instructors', and trainees' views, learning attitudes and receptivity towards those STEM activities?

The comments from FTC industry representatives were basically positive and satisfactory with regard to the trainees' learning attitudes and receptivity about the STEM activities, especially for those in-service practitioners – most of them really appreciate the dynamic and interactive approach during the STEM activities, which can enlighten them in the learning process. The instructors agreed that the overall participation and learning attitudes of trainees are good because they have interest in structured STEM activities. Reviewing the class and participants' observation recorded for the three treatment classes, the principal investigator discovered that most trainees often or very often showed their interest to learn, asked questions, were motivated in those STEM activities, collaborated in group work and frequently interacted with the instructors to complete the STEM activities during the lessons. These observations are consistent with the trainees' receptivity towards STEM activities. Furthermore, the focus group interviews with trainee representatives demonstrated that they like authentic learning with vivid and vibrant STEM activities that enable them to acquire new knowledge and skills with regard to technologies that are moving at the same pace in the modern society and are beneficial to their jobs. The principal investigator was very impressed by them saying that they will share their new knowledge with their colleagues in offices. Henceforth, the observations from classes together with the post-interviews with trainees after participating in the STEM activities triangulate positively what the FTC industry representatives and TVET trainers said about the good and positive learning attitude, participation and receptivity towards STEM activities in TVET.

5.2.3.2 What are the effects on the trainees' overall performance?

In general, the principal investigator concurs with the trainers and instructors that trainees exhibit a good and constructive learning attitude and they really enjoy the learning experience. The principal investigator believes this enjoyment can increase their memory of what they learn, as observed from the treatment classes conducted during this research study. Trainees usually do not have many expectations before a lesson. They might expect it will bear a certain relationship to their jobs as well as to know more about new knowledge in contemporary technologies. The discussions among principal investigator and trainees after the lessons and their reflections from the telephone interviews indicated that their expectations are satisfied. Most of their performance was positive and interactive during the lesson, and they claimed they will share new technologies they learnt with their colleagues after going back to their offices. Based on the observations of the class and participants, almost all the trainees finished the STEM activities on time during the lesson. It reflected that STEM activities could render positive learning effect on trainees' overall performance.

5.3 Hypothesis and Assumption

The null hypothesis is that STEM activities are not useful and practical to enhance trainees' learning experience in TVET to ensure a sustainable FTC industry. The principal investigator assumed all data were normally distributed, had homogeneous variance and participants with interest in STEM activities were selected.

5.4 Quantitative Data Interpretation

5.4.1 Validity

Validity is the test or proof for a true measure correctly adopted in a research study. Even though the sample size in the research is less than 50, but under the well-conditioned data, that is high level of loadings, low number of factors and high numbers of variables, EFA is still reliable for a below 50-case study, and also it is still considered to be valid below a small number of cases studied (de Winter et al., 2009). The results from KMO analysis is good and suggested the overall validity in the research methodology.

5.4.2 Reliability

Reliability is used to test for the consistent measurements, if the loading of Cronbach's alpha is good, that means the scale has higher internal consistency, which implies higher reliability. The overall result turns out from the Cronbach's alpha analysis is 0.84 which is good, that suggests the research methodology is highly reliable for the sample size during the research study (Johanson & Brooks, 2010).

5.4.3 Correlation

The result from the Kaiser Meyer Olkin value shows the sampling adequacy is good for exploratory factor analysis and all the items are related. Moreover, based on the result from the analysis, Bivariate correlation reflects that almost all of the nine items are strongly interrelated under the components content and practicability.

5.4.4 T-test

In order to investigate any significant influence of gender and work status on the STEM activities. Independent sample *t*-test is used to investigate the gender and work status differences in STEM activities.

Based on the result from the *t*-test, there is no significant difference on the genders male and female, which implies that sexes do not affect the overall performance on STEM activities during the workshops. With reference on the past old days of TVET, trainees normally come from the male gender, as TVET and job demands on the good old days were mainly on a craftmanship and hands-on basis. However, under the social and technological advancement in recent years, TVET tends to be more knowledge and technology based which embraces but not limited to problem precaution as well as rectification that goes beyond basic craft skillsets requirement. That implies more open and acceptable by the female gender from the workforce in the society. In fact, in the past research study, a surprising finding from Johnson (1987); Nakazawa & Takahira (2001); Weinburgh (1995) revealed that female's life experiences about science and technology were higher than male, like the sustainability issues of environment, earth science, biology and information technology.

Regarding the work group difference, there is only one trainee claimed part time and two trainees described themselves as other, the rest are all from full time working mode. Therefore, only two categories have been defined as "full-time worker" and "others". There is also no significance found from the statistical analysis which implies that various modes of working will not affect the overall performance of STEM activities during the workshops. This outcome is also a general phenomenon observed from the past to the present TVET patterns which include full-time, part-time as well as other types of trainees

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5.4.5 Anova-Post hoc

A one-way Anova test is utilized to investigate the relationship among subjects within the same subject factor. From the analysis on age group difference, one-way Anova is used to investigate any effect of age group on STEM evaluation scales, there is no significant difference between the youngest and middle age groups as well as the middle and oldest age group. However, there is significant difference between the youngest and oldest age groups found that indicate the youngest trainees and oldest trainees might have distinct preferences for the contents of STEM activities, a phenomenon that could affect the SES. On the other hand, significance might be due to the stark difference in age group sizes. Further investigation is required to dig out the truth behind. Regardless, the overall result shows that three age groups in the study cohort generally felt positive and satisfied with the contents as well as the practicability of the STEM activities.

Apart from studying age groups, STEM activity programs are also essential to investigate and see whether or not they have a certain relationship with the SES. As such, different treatment classes were designed with different STEM activities. Results reflected the effect of STEM activity programs were significant; there is a difference between thermal conductive textile and wool for sports STEM activities. Also, significance difference happened between thermal conductive textile and 3D fashion software STEM activities. There is only no significant difference found between wool for sports and 3D fashion software for STEM activities. These findings may indicate that some STEM activities are easier and less complicated to be handled by trainees or the class size influenced the final results. Therefore, further investigation may be required to examine the effect of different STEM activities under a uniform class size is needed for clarification.

As previously mentioned, there is a research gap in the interrelationship amongst STEM, TVET and the FTC industry. The quantitative survey reflected that trainees in general agree that STEM activities embedded in TVET are useful and practical and help them in their daily jobs in the FTC industry. In addition, the pedagogy with implementation of STEM activities in TVET can somehow benefit the in-service trainees that in turn benefit the industry as a whole.

5.5 Triangulation and Interpretation on Data

In general, data can be qualitative and quantitative, among other types. Triangulation is a method that facilities data validation through cross checking from two or more sources. By means of triangulation, the principal investigator can analyze the qualitative and quantitative data with the aim to increase the credibility as well as validity of the research study.

Cohen and Manion (2000) define triangulation as a means to map out or elaborate the complexity as well as richness of human behavior by analyzing it from more than one standpoint. Altrichter, Feldman, Posch, and Somekh (2008) claimed that triangulation can render a more detailed and balanced picture about the situation during study. According to

O'Donoghue and Punch (2003), triangulation is a methodology to cross check data collected from multiple sources to search for any regularities or consistence from the research data.

Overall, triangulation is a methodology to combine and analyze multi-research methods in the study of the same phenomenon in order to identify uncertainties, consistencies and narrow down the potential biases or problems arrived from a single source method in the research study. The ultimate goal is to maximize the strength of qualitative and quantitative data while minimizing the weaknesses that enable the data analysis to be comprehensive as well as reliable.

In this research study, there were two kinds of data collected. Firstly, the qualitative data involved data solicited from face-to-face structured interviews with open-ended questions from FTC industry representatives, TVET trainers and instructors, phone call interviews with trainees as well as the class/ participant observations. Secondly, the quantitative data solicited were through a questionnaire survey on trainees upon the completion of the STEM activities embedded in the treatment classes. Table 16 illustrated the results of triangulation on those data collected.

Hereunder are the interpretation on major findings from those results stipulated in the table 16 and relevant findings from the quantitative collected data.

Per information in table 16, it could be classified into seven sub-categories; namely (1) Training and Facilities, (2) Participation and Learning Attitude, (3) Outcomes and Benefits, (4) Pedagogy and Engagement, (5) STEM Activities and Objectives, (6) STEM and SD, (7) Difficulty in STEM Activities. It summarized that FTC industry representatives, TVET trainers and instructors as well as TVET trainees were all committed to basically STEM activities which could enhance TVET knowledge and skill competence for practitioners in the sustainable FTC industry. Class observations revealed that most of the trainees demonstrated great interest and positive learning attitude and participation as mentioned by FTC industry representatives as well as trainers during the interviews. The majority of the trainees enjoyed the STEM workshops, which was consistent with what the FTC industry representatives and trainers said. They reflected that trainees could be motivated and engaged with those STEM activities. Consistently, only a few participants showed a lay back attitude and were reluctant to experience those STEM activities. However, there was a significant difference in the age groups, the youngest and the oldest groupings during the analysis by SPSS. It might come from different age groups that had different interest reflected in the STEM activities conducted or the unbalanced group sizes compared in the research study. In addition, there were differences among some STEM activity programs. As mentioned above, that might be due to some contents in STEM activities which might have been easier or less complicated, including the operation of the equipment and facilities. Individual expectations and acceptability by trainees might have also led to the differences. The phone call interviews on trainees after the STEM activities also yielded extensive meaningful as well as more in-depth data related to the results.

In summary, triangulation was one of the possible means to reap the benefits from both quantitative together with qualitative methods so as to strengthen the credibility of knowledge by improving internal consistency as well as generalizability in the same research study. The overall results from the triangulation study was found to be highly consistent, justified the validity and reliability of results and revealed that FTC industry representatives, TVET trainers and TVET trainees indicate that STEM activities embedded in TVET could enhance knowledge and competence and be beneficial to challenging, sustainable industries.

Qualitative findings			**Quantitative findings**
Face-to-face interviews (FTCs &	**Class observations (Class A, B & C)**	**Phone call interview (TREs)**	**Questionnaire (TRES)**

TRRs)			
1. Training and Facilities			
• focus more on technology back up, big data, 3D CAD & CAM computer software	• trainees treasured a lot in the STEM activities by using VR headset and 3D technology & proposed new development in products	N/A	N/A
• genuine practice on machineries	• trainees were very often to demonstrate interest to learn and practice in the computer	• training venue should be equipped with more facilities to support & enhance learning	N/A
• 3D computer software, hands-on works & synergy with industries were vital	• trainees were practicing on the computer software with high concentration & raised questions which led by the instructor & technician during the workshop • trainees could make use of the knowledge and skill learnt & applied in their virtual garment design as well as virtual fitting on an avatar	• good to have more time on practice as well as hands-on works via experiencing STEM activities	N/A

2. Participation and Learning Attitude			
• trainees & in-service practitioners demonstrated good participation with good & positive learning attitudes during workshops	• trainees often showed interest to listen, learn and actively participated in the STEM activities • trainees very often posted up questions proactively & engaged in the discussion as well as successfully complete the STEM activities with good interaction • trainees liked the demonstration & enjoyed the practice	• showed interest during demonstration and positive participation during STEM activities • STEM activities were playful and felt good in the authentic learning process	• most of the trainees loved the content & STEM activities in the courses • in general, respondents were satisfied with the STEM activity programs
3. Outcomes and Benefits			
• trainees' learning outcomes were positive & effective	• A few trainees showed lay back and reluctant to participate & experience the STEM activities	• STEM activities were useful to certain extend • committed that STEM workshop was effective and learnt some solid new things	• the average score of SES (M=3.99, SD=.500) which tended to be positive and good as well as forming a normal distribution curve • almost all the trainees agreed

			STEM activities could motivate & enhance their learning outcomes
• agree STEM activities in TVET was beneficiary to the sustainable industry	• trainees expressed the workshop content was useful, practical & reachable to their daily jobs	• STEM activities were helpful in application & beneficiary to their jobs • a lot of queries could be settled through the STEM activities • would share what had learnt in the workshop when back to office	• respondents recognized the practicability & usefulness of the STEM activity programs • most of the trainees disagreed STEM activities were not useful & applicable to their daily life or existing jobs
• satisfied with trainees from TVET on skillsets & competence that fit into the industries	N/A	• agreed STEM activities allowed more understanding in new technologies for self-upgrading in the modern society & useful to jobs	• majority of trainees reflected STEM activities could help their knowledge understanding & master the skillsets effectively
• agreed STEM activities were able to enhance trainees from TVET in knowledge & skill competence basis to meet the	N/A	• agreed STEM activities were able to enhance them from TVET in knowledge & skill competence basis to meet the challenging	• almost all the trainees committed STEM activities could enhance TVET for practitioners from the FTC

challenging sustainable industry in 21st Century		sustainable industry in 21st Century	industries
4. Pedagogy and Engagement			
• STEM could act as a tool in pedagogy to enlighten learning & arouse creativity	• trainees were highly motivated & successfully completed the STEM activities in lessons with interaction & feedbacks	N/A	• majority of the trainees enjoyed the course with STEM activities embedded
• to explore & incorporate STEM activities to engage trainees & keep up their lifelong learning path	N/A	• subject to the relevancy among STEM activities, methods & the nature of jobs	N/A
5. STEM Activities and Objectives			
• STEM activities were actual practice during workshop, digging out problems & finding feasible solutions in the whole learning process	N/A	N/A	N/A
• STEM activities should be well defined & focused in the Project-based learning	N/A	• A few trainees did not know the workshop was STEM activities based and not much	N/A

approach		expectation before participation	
6. STEM and SD			
• mentioned STEM elements, ethics & compliance were essential in TVET to help environmental sustainability	N/A	N/A	N/A
7. Difficulty in STEM Activities			
• difficulty & limitation in resources, management support as well as funding allocation	N/A	• not many to negligible difficulty encountered	• majority of trainees disagreed STEM activities were complicated and difficult to master at all

Table 16. Triangulation among the key qualitative and quantitative data

Remarks:

Class A: Smart Technologies and Thermal Conductive Textiles
Class B: Wool for Sports 2019 with Technology Highlights
Class C: CLO 3D Fashion Software CAD Workshop

The overall result is quite positive and encouraging with regards to the implementation of STEM activities in TVET for the practitioners from the FTC industry demonstrate that the practitioners commit to the usefulness and practicability of STEM activities embedded in the TVET courses. Hence, STEM activities infused in TVET courses can definitely benefit the practitioners as well as the sustainable FTC industry effectively.

5.6 Validity of Data (Language Barrier and Sample Size) and Possible Limitations

There are two important threats to the validity of a research study: the selection of data that align with the investigator's goals and preconceptions and sorting data that is contrary to the investigator's expectation (Miles & Huberman, 1994, p. 263; Schweder, 1980). In the actual practice during the research study, a researcher or an investigator should try to avoid a selective expectation mindset and biases when interpreting results and findings; these aspects will affect the entire validity of the outcomes in the study. Rather, those actual findings and results might lead to new insights or surprises in the research topic that have implications for future research.

A potential language barrier is vital and needs to be considered and excluded during qualitative and quantitative surveys. Actions such as performing a trial run, pilot test and thorough briefing as well as clarification with participants are essential prior to the commencement of the study.

Finally, Maxwell (2011, pp. 64–65) reiterated that small sample size, inadequate information solicited from qualitative and quantitative instruments, overemphasis on common features, ignoring minimal differences or putting up far-fetched theories with respect to the collected data may also influence the validity. Last but not least, a larger scale of quasi-experimental study with more contexts in STEM activities as well as bigger population size of participants is recommended for future work, such a study could then be more generalized and transferable to other trades in the industry.

Chapter 6 Conclusion and Implications

The conclusion has been drawn based on the mixed methods of qualitative and quantitative analysis, class and participant observation, the principal investigator's observation during the delivery of treatment classes together with his years of experience from the FTC industry as well as vocational education and training. Henceforth, the present findings will provide some useful information to fill up the aforementioned knowledge gap. Furthermore, implications and insights are derived for further research and consideration.

6.1 Conclusion

Regarding the research project 'Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry', overall feedbacks from the FTC industry representatives, TVET trainers and instructors as well as the in-service trainees from the industries mostly agree that STEM activities can enhance knowledge and skill competence to meet the challenging sustainable development focus in the twenty-first century. Trainees also provided positive comments on practical training, interactive participation and an authentic application. The principal investigator echoes the participants that 3D CAD software will be a prominent trend in many garment companies in the near future. He also observed first-hand the positive reactions of trainees during the research study and agree with what Morrison (2006) wrote: "STEM education and training can make students better problem solvers, inventors, innovators, logical thinkers, self-reliant as well as technologically literate".

The quantitative analysis verified the trainees' overall positive comments on the usefulness of STEM activities embedded in TVET and high practicability directly related to the industry although significant differences existed between the youngest and the oldest age groups and STEM activity contents which need further research. The qualitative investigation provided more details and insights to support the research study, such as the usefulness of 3D scenarios via computer-mediated 3D virtual design, fitting and catwalk presentation. 3D CAD and CAM in paper pattern manipulation and fabric cutting together with big data processing are good additions to STEM activities that increase the incentive and involvement of trainees in their experience and learning process. Indeed, the principal investigator was quite impressed by one participant's comment on mobile gamification about adopting an AR program to engage trainees during the learning process; this approach could increase training success. The principal investigator agrees with most of the industry representatives that TVET has a high value to provide feeders to ensure a sustainable FTC industry. STEM knowledge training is essential nowadays because it is an inquiry-based approach on problem prevention rather than solving problems when they arise. With respect to the global shift towards environmental sustainability, current contexts and technologies are required in STEM education and training in order to support and enhance TVET to ensure a green FTC industry. Furthermore, it is vital to cooperate with industry partners in a WIL mode, which will allow more efficient and effective training outcomes.

Upon conducting the research study, the principal investigator can see many areas and new ideas to advance and improve STEM activities. Overall, the industry representatives and trainers did not mention negative impacts of TVET; they reiterated the importance of technologies and adequate resources including funding and industry collaboration in order to drive STEM activities to match with the FTC industry. Areas for improvement can be summarized after the feedback from trainees from those treatment classes. First, the practical STEM activities could be increased in length to enhance learning and understanding. Second, the content of STEM activities and products could be split up into semi-finished or dismantled product parts that show cross sections as well as inner structural working mechanism; especially how the graphene and electronic system are being designed and engineered into textile of the garment, these models can convey more explicit information about the process during training. Finally, an intermediate STEM training course could be arranged with a wider spectrum of topics and raw materials for trainees. In summary, various STEM activities – for example, virtual garment design and prototypes that reduce unnecessary sampling, waterless dyeing and finishing that alleviates discharge of toxic waste-water – can be considered to enrich and enhance an effective STEM education in vocation training. This endeavor seems to be essential for the future success of a sustainable industry!

6.2 Implications

The completion of the entire research study has sparked quite a few implications that encompass, but are not limited to, the invaluable comments from FTC industry representatives. The following are the implications or insights for reference and consideration.

6.2.1 Knowledge Archives/Knowledge Engineering Center

The principal investigator strongly supports the establishment of industry-specific knowledge archives, for instance, knowledge archives for the FTC sector. This action can benefit practitioners by shortening lead times and providing a platform to widely share past problematic cases and facilitate their solutions under the bloom of the ICT system.

6.2.2 Belt and Road Initiative: The Greater Bay Area

It is important to consider the job opportunities under the Belt and Road Initiative advocated by the Chairman of the People's Republic of China, in particular the Greater Bay Area. Under structural changes in industries and prevalent trends in technologies, TVET has become more acceptable by the general public and employers from industries. The principal investigator echoes some comments from industry representatives in that TVET should focus and prepare trainees for future engagement in the Greater Bay Area.

6.2.3 Co-brain and Co-work in STEM

Basically, students' academic achievement depends not only on the ability of the instructor, but also the interaction among students usually in form of collaborative or cooperative learning processes occurring a classroom context (Yeung, 2006). With regard to some feedback from industry representatives, STEM knowledge in local TVET has not reached an optimal level because the manufacturing base is mainly located in Mainland China. Therefore, it will be better to collaborate with technicians and professionals from Mainland China on STEM development. Indeed, local TVET works hand in hand with the TVET institutions in Mainland China via PBL projects. This collaboration should enable more interactions with trainees from different countries; they can learn and work together while exchanging views that can broaden their visions and mindsets on new things in the world.

6.2.4 Interdisciplinary Collaboration

As previously mentioned, STEM has been prevalent in the United States since the early nineties. In recent years, policies in HKSAR – fully supported by the Education Bureau – have advocated that secondary schools embed STEM in the classroom to motivate learning and problem solving. Research has also indicated that adopting interdisciplinary or integrated curriculum provides chances for less fragmented, more relevant and more stimulating experiences for the learner (Furner & Kumar, 2007, p. 186). During the learning process, it encourages interdisciplinary collaboration. For example, setting up a creative topic on product about the application of solar energy requires IT technician using a computer to design and draw up the electronic circuit diagram, then passing it on to engineers to assemble it; science and mathematics are required for testing and evaluating the products for effectiveness and efficiency. As such, students from various disciplines can learn and work together on a project and share the final results. This endeavor embraces creative thinking skill, communication skill, problem solving skill as well as team-work building skill, all of which are advocated 21st century competencies.

6.2.5 Reindustrialization in HKSAR

Reindustrialization is being highlighted in HKSAR; one example is from the redevelopment a yarn mill located in the New Territory Tai Po re-develop to provide advanced technology with regard to recycling yarns and textiles. The Innovation and Technology Commission launched the reindustrialization and technology training program (RTTP) in August 2018 – under the Technology Talent Scheme of the HKSAR government. The RTTP subsidizes local companies on a 2:1 matching basis to train practitioners in advanced technologies related to Industry 4.0, with an aim to nurture as well as bring together more and more technology talent (ITF, 2020).

As mentioned by the industry representatives and TVET trainers, the HKSAR government should help advance the technology and related STEM activities to benefit the economy and industry. Given that there are more than 80% of the small and medium-sized enterprises (SMEs) in the FTC industry in HKSAR, the principal investigator totally agrees that they can take advantage of this scheme for their employees to re-skill or upskill in the contemporary industry.

6.2.6 Re-skilling/Upskilling with Green Skills

The principal investigator concurs with some comments from industry representatives that the fundamental skills are the minimum required to meet industry demands. There should be more vibrant learning and flexible application in workplaces to ensure better horizontal and vertical movement within the industry sectors. Thus, re-skilling and upskilling in green skills are crucial, especially for the future challenge in the Greater Bay Area. Green skills comprise methods that consider the eco-concept, such as e-commerce, e-sampling and e-tailing, all of which are likely to become prevalent in the future. These so-called green skills and green technologies can diminish the carbon and water footprints as well as energy consumption under the global macro trend of SD.

6.2.7 Interrelationship of TVET, STEM Skills, Lifelong Learning and Sustainability

STEM seems to be the essential element in TVET to ensure consideration of the eco-concept. The principal investigator concurs with industry representatives that "STEM-VET" can make SD bloom. Under Industry 4.0, ICT and big data processing enable the 3D simulation of textiles, which can avoid resource waste such as excessive weaving and finishing of textiles and minimize emissions as well as potential environmental contamination that help to save the earth.

The FTC industry is facing the challenge of environmental sustainability, especially carbon and water footprints. While waterless dyeing sounds good, the principal investigator wonders if the potential fiscal costs of the recycling process will become another vital issue. In other words, technology can alleviate environmental pollution while actually increasing the amount of money it takes to produce products. To strike a balance, the principal investigator thinks technology needs to advance hand in hand with reductions in recycling costs at the same time.

6.2.8 Skills for the Future

The principal investigator believes that innovation in design and technology is of the utmost important for environmental sustainability, textile bio-recycling, textile upcycling, garment-to-garment (G2G) recycling, bio-degradable materials, zero-water textile processing and functional textile development, among other novel concepts and advanced technological supports that will ensure SD. Moreover, digital skills, like cloud computing, competence and basic programming knowledge are essential in tech-driven environment. Green skills and advanced technologies seem to be the means to allow mankind to live on a sustainable planet. This endeavor requires embracing the development of high-tech green manufacture, information and communication technology, digitalized workplaces, personalized production, artificial intelligence and smart supply chain management, among others. STEM can act as a tool and vital in TVET to help preparing trainees and industry practitioners develop environment sustainable industries. Furthermore, the principal investigator commits that the WIL approach in the industry along with a lifelong learning pathway can allow trainees as well as practitioners to stay abreast in the challenging world today and tomorrow.

Regarding the jobs for the future, tomorrow's jobs will be very different from those of today, it encompasses but not limited to green jobs in construction sector, technology and big data, hospitality and tourism, creative industry, agriculture as well as manufacturing industry under the "industry 4.0" revolution which is noteworthy to be discussed (Deloitte, 2014).

6.2.9 Manpower Structural Reform

Since students' interests in science are often good predictors for their future choices of tertiary education and professional careers in related science and technology fields, as such, the government of HKSAR and Mainland China should pay more attention to create plans or policies that address the supply and demand of manpower required to fill positions in the relevant science and technology professions in coming years (Yeung, 2015).

Entering into the era of Industry 4.0, the development of cyber physical systems, the

Internet of things, computer networks, artificial intelligence, digital workplace, automation in production and so on have improved and will continue to improve the living standards of mankind. At the same time, it also induces changes in the labor force structures. Professionals such as managers, technologists and technicians seem to be on the right track; however, operators and unskilled workers might encounter difficulties in modern society and advanced industries. Hence, we must consider whether re-skilling and up-skilling provide access to the new era in order to survive and sustain.

Last but not least, the principal investigator personally supports the traditional slow fashion approach in production: this process normally takes a couple of months and offers more sustainable and ethical ways to produce products; it incorporates innovative and fashionable designs; and it smartly consumes material and utilize sustainable bulk production (Clark, 2008). Slow fashion is an attempt to convince consumers to purchase fewer cloths and keep them for longer use (European Parliamentary Research Service, 2019). This approach seems more sustainable than the fast fashion approach where goods are produced and delivered within a few weeks. European Parliamentary Research Service (2019) pointed out that fast fashion relies on mass production, low price and large volumes of sales which led to consumers to see cheap garment items increasingly as perishable goods that are "nearly disposable," and that are thrown away after wearing them only a couple of times.

6.3 Improvement Plan for Future Research Studies

6.3.1 Continuous Improvement Plan

The aim of this action research is to allow the researcher or investigator who is the taking the role of the instructor in the in-service training course to aware and carry out continuous improvement in the teaching and learning methods via STEM elements and activities incorporated in the course to facilitate as well as enhance the in-service practitioners' skills and competence in their STEM careers. Therefore, improvement plan below is based upon the results from the treatment classes with STEM activities embedded as well as the research finding. These changes will be adopted into future classes so as to demonstrate the improvement actions under the Plan-Do-Check-Act (PDCA) cycle respectively.

6.3.2 Teaching and Learning Packages

Based on the finding from the research study, teaching and learning packages (TLPs) can be adopted in e-documents. Student notes, handouts, supplementary printouts, project brief are all distributed via computer links, QR codes and so on in order to avoid making hard copies. This approach contributes to SD and advocates digitalization in learning, which is one of the major competencies in the 21st century.

In addition, a teaching and learning packages can be formulated in instructor's manual/handbook which systematically include theories, case studies, demonstration, experimental set up, analysis and problem-solving guidelines for effective practice in pedagogy thereafter. By the way, STEM can be acted as tool in pedagogy by adopting POE and innovative proposal in real-world application.

6.3.3 STEM Activities

Based on the feedback from the classes, there were few problems and difficulties encountered during the workshop. Thus, the principal investigator was inspired to think of more intricate STEM activities involving deconstructing and reconstructing of semi-products or parts during the practical learning. Besides, under the global TEL trend, a laboratory or workshop with more space, facilities and advanced equipment can be considered for practical training in TVET in the near future. Last but not least, to avoid training courses that have too much content, intermediate courses can be arranged as follow up activities.

As opinions on how STEM education and training should be advanced vary across school contexts, curricula, and political arenas. It addresses but not limited to the approaches to STEM integration, extending STEM to STEAM (including element of art) and so on (English, L.D., 2017). However, with reference to the literatures, despites increasing in STEAM education efforts, many researchers reported teachers' difficulties in STEAM education, they normally suffer from insufficient time for and lack of educational materials for implementing STEAM education in schools (Geum & Bae, 2012; Lee et al., 2012, 2013; Lee & Shin, 2014; Shin & Han, 2011). Besides STEM, STEAM learning has also become a huge educational movement in some countries with related activity like Tie-dye in textile and clothing (Dziengel, 2015). Therefore, it is noteworthy to carry out further research in STEAM education and related activities in the next stage.

6.3.4 Work-integrated Learning (WIL)

Technical and vocational education and training (TVET) comprises knowledge-based education, training as well as skill sets development in relation to the occupational fields, production, services and livelihoods. It aims to prepare feeders or successors to meet the quality and manpower demands in relevant industries. One of the comments from the industry representatives is that TVET should also prepare trainees to reach out to other markets that have great potential and are globally diversified with regard to development. To achieve that aim, WIL in the industry is absolutely essential and, indeed, inevitable. The principal investigator concurs with Sako (1994), who was proud of his work-based TVET with pedagogical skills of supervisors and experienced workers, strong encouragement to engage workers in self-development, as well as informal skills like job rotation and seamless quality control. WIL is not limited to local industry; it is also open to foreign commerce and industrial sectors. Hence, the principal investigator highly recommends that TVET incorporate a certain number of hours for WIL in the training curriculum.

6.3.5 Interdisciplinary Collaborations

Basically, the principal investigator pretty much believes with the concept on interdisciplinary collaboration which can share the niche, expertise and professionalism from various parties that is good to encourage creative thinking skill, communication skill, problem-solving skill as well as team-work building

6.3.6 Proposed Further Study on other STEM Activities

Most of the trainees from those treatment classes were satisfied and agreed the STEM activities are useful and practical for their jobs. They liked the STEM activities and found that they enabled them to acquire new knowledge on technologies and in-depth understanding with real practice and the ability to share and interact. STEM activities are encouraged and supported in contemporary education and training. In particular, the advocacy of sustainable industries, more focus should be put on STEM with green technologies embedded.

The principal investigator has spent more than six months on the research study, collecting results and analyzing the data. While the findings have been very insightful and have helped to answer the research questions, social unrest in Hong Kong and the COVID-19 pandemic have greatly affected the class sizes. This phenomenon might have led to unnecessary bias from the small sample size and influenced the analytic results.

In order to gather more representative data that support the research findings, the principal investigator proposes examining other STEM activities that are applicable to FTC areas. This endeavor will help exclude limitations due to a small sample size or the type of STEM activity. Other STEM activities that can be embedded in TVET courses aimed towards individuals in the FTC industry are fur and leather design; garment paper pattern drawing; seamless sweater knitting; digital inkjet textile printing; 3D printing on fashion accessories; and yarn and textile evaluation.

By doing so, it hopes "STEM-VET" can cover more areas, especially the up-to-date technologies in order to move TVET forward to align the sustainable focus advocated by the FTC industry under the global direction in the sustainable development.

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Author Biographies

Mr. Benny HWONG is the head of a vocational education and training center (Fashion Textiles) in which offering pre-employment and in-service training programs for pre-service and in-service practitioners from FTC industry in Hong Kong. He has devoted most of his time and experience in curriculum design and development, pedagogy as well as synergy with the FTC industry. Undoubtedly, his strong academic backgrounds in fashion design, product development, merchandising, marketing, production and quality assurance together with profound experience in fashion trading and industry that can enable him to conduct the research efficiently and reliably.

Benny's research focuses on 'STEM-VET' and hoping it can be promoted as a major innovation and setting the scene for lifelong learning in the sustainable FTC industry under the global direction on sustainability.

Furthermore, Benny possesses the following memberships with active participation and contribution: CITA, HKFTU, HKRITA, HKWAIU and IFDMA.

Appendices

Appendix A (List of Interview Respondents)

FTC industry representatives (face-to-face interviews)		
Coding	Post	Organization
FTC_01	Design Director	Kalico Design Limited
FTC_02	Senior Manager	Glorisun Enterprise Limited
FTC_03	Senior Teaching Fellow	Institute of Textile and Clothing, HK PolyU
FTC_04	Chairperson	Hong Kong Wearing Apparel Industry Employees General Union (HKWAIU)
FTC_05	Chairperson	International Fashion Design Management Association (IFDMA)

Trainer representatives (face-to-face interviews)		
Coding	Post	Organization
TRR_01	Full time lecturer	Vocational Training Institution
TRR_02	Full time instructor	Clothing Industry Training Authority, CITA
TRR_03	Part time lecturer	Education and Training Center
TRR_04	Part time instructor	Kurabo Industries Limited

Trainee representatives (phone call interviews)	
Coding	Post
TRE_01	Industry Practitioner
TRE_02	Industry Practitioner
TRE_03	Industry Practitioner
TRE_04	Industry Practitioner
TRE_05	Industry Practitioner
TRE_06	Industry Practitioner
TRE_07	Industry Practitioner

Appendix B (Interview Protocols)

Thesis Interview Questions (1)

Project title: Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry

General interview parties: Employers/ Associations/ Chambers/ TVET Professionals or Trainers

Background and Aims:

This survey is a part of the research project that solicit and examine views and comments from the representatives in the Fashion Textile and Clothing Industry on the main problems, deficiencies of practitioners and current needs of the industry. Also, their perspectives on the STEM and TVET in Hong Kong.
The survey explores how STEM activities embedded in the vocational training can benefit and sustain the industry in the contemporary era.

Instructions:

The information that you provide will help us to understand and identify the current practices, needs and deficiency in the industry. So that we can investigate how can STEM activity in TVET make contribution to the sustainable industry.

All questions are mainly focused in Hong Kong environment and divided into five sections enlisted underneath. Clearly inform the interviewees that their participation in this interview is absolutely voluntary. Your feedback will be treated with confidentiality and will not use for other purpose other than the captioned research project.

At the end of the survey, you can add information you feel is important which has not been addressed in the survey. Your responses will be very much valued and thank you for agreeing to complete this survey.

Section	**Aspect of Questions**

A	**Fashion Textile and Clothing Industry (FTC industry)**
B	**TVET and Professional Recognition in Hong Kong**
C	**STEM Elements and Activities in TVET Curriculum**
D	**Relationship between TVET and Sustainable Industry**
E	**Attitudes, Skills & Competence of trainees / graduates from TVET organization**
F	**Views on future development and advancement in TVET**

Section A – Fashion Textile and Clothing Industry (FTC industry)

Q1. What is your overview for FTC industry in Hong Kong?

Q2. What are the current and future needs for the quality and capacity of manpower in the FTC industry?

Q3. Is there any problem or deficiencies in the current in-service practitioners?

Section B – TVET and Professional Recognition in Hong Kong

Q4. What do you think the trend of TVET in the FTC industry?

Q5. Any professional recognition of TVET in FTC industry?

Q6. Do you have any perspectives on TVET and TVET trainees in Hong Kong?

Q7. How about the acceptance of TVET by general public and employers nowadays?

Section C – STEM Elements and Activities in TVET Curriculum

Q8. How much do you know about STEM?

Q9. What should be the focus on TVET training curriculum and facility?

Q10. Do you agree to explore and incorporate STEM activities in TVET curriculum or courses?

Q11. How to implement STEM activities in TVET curriculum or courses in Hong Kong? What are the resources required?

Q12. What do you think about the STEM knowledge level of TVET trainers in Hong Kong?

Q13. How effectiveness you guess the STEM activities in TVET benefits the sustainable industry?

Section D – Relationship between TVET and Sustainable Industry

Q14. What are the challenges that FTC industry is facing in order to achieve the environmental sustainability?

Q15. Do you think TVET bears a high value in providing feeders to a sustainable Fashion Textile & Clothing Industry?

Q16. If yes, what are the elements in TVET for a sustainable industry?

Q17. How would you link up STEM, TVET and SD in industry?

Section E – Attitudes, Skills & Competence of trainees/ graduates from TVET Organization

Q18. Do you have any comment on the learning attitude of trainees in TVET embedded with STEM activities?

Q19. What are your views on skills & competence of TVET trainees in mapping with the FTC industry?

Q20. Do you think the employability & mobility of practitioners from TVET is good or not?

Q21. In general, do you think employers satisfy with the performance of the current practitioners (level of skill sets and depth) from the industry? Why?

<u>Section F - Views on future development and advancement in TVET</u>

Q22. Do you have any new idea for TVET to develop and advance?

Q23. Any negative impact from TVET received from the industry so far?

Q24. Overall speaking, could STEM activities be able to enhance trainees from TVET in knowledge and skill competence basis to meet the challenging sustainable industry in 21st Century?

Q25. Any other information you feel is important which has not been addressed in the survey?

Abbreviation:

SD – Sustainable Development
STEM – Science, Technology, Engineering, Mathematics
TVET – Technical and Vocational Education and Training

Thank you

End

Thesis Interview Questions (2)

Project title: Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry

General interview parties: Trainers/ Instructors/ Lecturers in TVET for FTC industry.

Background and Aims:

This survey is a part of the research project that solicit and examine views and comments from the representatives in the training field of Fashion Textile and Clothing Industry on the STEM activity, implementation, resources, expected outcomes as well as effectiveness in TVET in Hong Kong.
The survey explores how STEM activities embedded in the vocational training can benefit and sustain the industry in the contemporary era.

Instructions:

The information that you provide will help us to understand and identify the practices, needs and deficiency in the implementation of STEM activity in TVET. So that we can investigate how can STEM activity in TVET make contribution to the sustainable industry.

All questions are mainly focused in Hong Kong environment and divided into five sections enlisted underneath. Clearly inform the interviewees that their participation in this interview is absolutely voluntary. Your feedback will be treated with confidentiality and will not use for other purpose other than the captioned research project.

At the end of the survey, you can add information you feel is important which has not been addressed in the survey. Your responses will be very much valued and thank you for agreeing to complete this survey.

Section	**Aspect of Questions**

A	**Implementation of STEM-based activity in TVET**
B	**Difficulties and constraints in practical workshops**
C	**Resources and facilities required**
D	**Trainee's learning attitude & receptivity in STEM-based activity**
E	**Overall outcomes and effectiveness in performance**
F	**Views on future development and advancement in STEM-based activity**

Section A – Implementation of STEM-based activity in TVET

Q1. What is your overview for the implementation of STEM activities in TVET courses?

Q2. How to implement the STEM activities?

Section B – Difficulties & constraints in practical workshops

Q3. What are the difficulties and/ or constraints encountered during implementation?

Q4. How could those difficulties and/ or constraints be overcome?

Section C – Resources and facilities required

Q5. What are the resources and facilities required for full implementation?

Q6. How are you going to incorporate those resources and facilities as well as the costing concerned?

Section D – Trainee's learning attitude & receptivity in STEM-based activity

Q7. How about the trainees' learning attitude and receptivity during the workshops embedded with the STEM activities?

Section E – Overall outcomes and effectiveness in performance

Q8. How about the overall participation of trainees in the workshop?

Q9. What are the learning outcomes including knowledge, skills and/ or attitude in STEM observed?

Q10. What do you think about the effectiveness of STEM activities embedded in the TVET courses for FTC industry?

Section F - Views on future development and advancement in STEM-based activity

Q11. Do you have any new idea for STEM-based activity to develop?

Q12. Any negative impact from STEM-based activity received so far?

Q13. Overall speaking, could STEM activities be able to enhance trainees from TVET in knowledge and skill competence basis to meet the challenging sustainable industry in 21st Century?

Q14. Any other information you feel is important which has not been addressed in the survey? Or you have other additional comments.

Abbreviation:

FTC – Fashion Textile and Clothing
STEM – Science, Technology, Engineering, Mathematics
TVET – Technical and Vocational Education and Training

Thank you

End

Phone Call Interview Questions (3)

Project title: Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry

General interview parties: Trainees/Students in TVET for FTC industry.

Background and Aims:

This survey is a part of the research project that solicit and examine views and comments from the trainees/ students from TVET courses about the feedback on the STEM activity, learning attitude, participation, receptivity and expected outcomes as well as effectiveness of the lesson.
The survey explores how STEM activities embedded in the vocational training can benefit and sustain the industry in the contemporary era.

Instructions:

The information that trainees provided will help us to understand and identify the needs, participation and effectiveness in the implementation of STEM activity in TVET. So that we can investigate how can STEM activity in TVET make contribution to the sustainable industry.

All questions are mainly focused in five different sections enlisted underneath. Clearly inform the interviewees that their participation in this interview is absolutely voluntary and their feedback will be treated with strict confidentiality and will not use for other purpose other than the captioned research project.

At the end of the survey, trainees can add information they feel is important which has not been addressed in the phone call survey. Your responses will be very much valued and thank you for agreeing to complete this survey.

Section	**Aspect of Questions**
A	**Learning attitude on STEM-based activity in TVET**

B	**Participation in the practical workshop**
C	**Receptivity of STEM-based activity**
D	**Overall outcomes and effectiveness in performance**
E	**Views on future development and advancement in STEM-based activity**

<u>Section A – Learning attitude on STEM-based activity in TVET</u>

Q1. Do you think STEM activities are useful in TVET courses?
If yes, what are they and why?

你覺得培訓課程內之 STEM 活動，對課程有幫助嗎？如是，那是什麼及為何？

Q2. Do you think STEM activities is interesting or not?
If yes, what are they and why?

你覺得 STEM 活動有趣嗎？如是，那是什麼及為何？

<u>Section B – Participation in the practical workshop</u>

Q3. Do you like to participate in the STEM activity?
If yes, what are they and why?

你喜歡參與 STEM 活動嗎？如是，那是什麼及為何？

Q4. Any problem or difficulty during the participation?
If yes, what are they and why?

在參與中，有沒有遇到什麼問題或困難？如是，那是什麼及為何？

<u>Section C – Receptivity of STEM-based activity</u>

Q5. To what extend you accept STEM activity embedded in TVET course?

在培訓課程中加入 STEM 活動，你的接受程度是怎樣？

<u>Section D – Overall outcomes and effectiveness in performance</u>

Q6. What is your expected outcome before participating in the TVET embedded with the STEM activities?

在參與培訓課程和 STEM 活動前，你期望有什麼結果？

Q7. Does the course and STEM activity meets your expectation
If yes, what are they and why?

經過培訓課程和 STEM 活動後，能否滿足你的期望？如是，那是什麼

及為何？

Q8. How about the overall effectiveness you would like to comment?

你對整體的效益有什麼評論？

Section E - Views on future development and advancement in STEM activity

Q9. Do you have any new idea for STEM activity to develop?
If yes, what are they and why?

你對 STEM 活動的發展有沒有新的意念？如是，那是什麼及為何？

Q10. Any areas or aspects for improvement on STEM activity you would like to comment?

你認為 STEM 活動有沒有空間去改善或評論？

Q11. Overall speaking, could STEM activities be able to enhance you or most of you as trainees from TVET in knowledge and skill competence basis to meet the challenging sustainable industry in 21st Century? If yes, what are they and why?

整體而言，STEM 活動是否能加強學員在培訓中的知識及技能

去面對在廿一世紀行業上的挑戰？如是，那是什麼及為何？

Q12. Any other information you feel is important which has not been addressed in the phone survey? Or you have other additional comments/ concerns/ suggestions?

如在這電話訪問內容上沒有談及，你有沒有其他重要事項補充或建

議？

Abbreviation:
FTC – Fashion Textile and Clothing
STEM – Science, Technology, Engineering, Mathematics
TVET – Technical and Vocational Education and Training

Thank You

END

Appendix C (Questionnaire Protocols)

Sample Questionnaire Instrument for focus group of trainees

Thesis Questionnaire (4)

Questionnaire survey about TVET course & STEM activity

問卷調查**:** 關於職業教育與培訓課程內容及 **STEM** 活動

STEM 活動包括實習 / 體驗 / 分析 / 演繹 / 應用等等。

Trainees in the technical & vocational education & training (TVET) course/ seminar workshop

職業教育及培訓課程/ 講座工作坊內之學員

1. Name 姓名**:**

   ____

2. Your Sex is / 性別:

   ☐ Male

   ☐ Female

3. Your age group is / 年齡組別:

   ☐ 11-20

   ☐ 21-30

   ☐ 31-40

   ☐ 41 or above

4. Your current status is / 現況:

   ☐ Full time working

   ☐ Part time working

   ☐ Full time or part time studying

☐ Others

5. I understand the course content & STEM after completion of this course.

本人在完成課程後,明白本課程之內容及 STEM 活動。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

6. I like the content & STEM activities in this course.

本人喜歡課程之內容和 STEM 活動。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

7. STEM activities in this course help me understand the knowledge and master the skill sets effectively.

課程內的 STEM 活動，能協助本人了解及有效地掌握相關知識與技能。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

8. STEM activities are complicated and difficult to master.

STEM 活動是複雜和難於掌握。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

9. STEM activities are not useful and applicable to my daily life or existing job.

STEM 活動用處不大及對本人日常生活或工作應用亦不大。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

10. I enjoy taking the course with STEM activities embedded.

本人喜歡就讀一些含有 STEM 活動的課程。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

11. STEM activities can motivate and enhance my learning outcomes in the course.

STEM 活動能夠激發及加強本人於課程內之學習成果。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

12. I will recommend my friends or colleagues to enroll in STEM-based training course.

本人會推薦朋友或同事去報讀含有 STEM 活動之培訓課程。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

13. Overall speaking, STEM activities can enhance TVET for practitioners from the Fashion Textile and Clothing industry.

整體而言, STEM 活動能夠加強時裝紡織及服裝行業之從業員在職業教育與培訓課程中的成果。

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立 / 沒意見

☐ Agree 同意

☐ Strongly agree 絕對同意

14. I would like to provide the following information or comment which has not been addressed in this questionnaire.

因在此問卷調查沒有提及到，現本人欲提供如下資料或評論作參考：

____

____

____

____

____

Abbreviations 簡稱

STEM – Science, Technology, Engineering, Mathematics
科學，科技，工程，數學
TVET – Technical and Vocational Education and Training
職業教育與培訓課程

END 完

Thesis Questionnaire (Pilot Study)

Topic : Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry

透過 **STEM** 活動教學在職業教育與培訓來促進可持續發展之時裝紡織及服裝行業的行動研究

Sample Questionnaire for

問卷樣本給

Trainees in the training courses of Spare Time Study Center (STSC)
業餘進修中心訓練課程內之學員

1. Name 姓名:

____

3. Your Sex is 性別:

☐ Male

☐ Female

3. Your age group is 年齡組別:

☐ 11-20

☐ 21-30

☐ 31-40

☐ 41 or above

4. I understand what is STEM after completion of this course.

本人在完成課程內之活動,明白甚麼是 STEM

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

5. I like STEM activities in this course.

本人喜歡課程內之 STEM 活動

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

6. STEM activities should always be embedded in TVET.

STEM 活動應時常包括在職業教育與培訓課程中.

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

6. STEM activities in this course help me understand the knowledge and

master the skill sets effectively.

課程內的 STEM 活動,能協助本人了解及有效地掌握相關技能.

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

7. STEM activities are complicated and difficult to master.

STEM 活動是複雜和難於掌握

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

8. STEM activities are not useful and applicable to my daily life or existing job.

STEM 活動用處不大及對本人日常生活或工作應用亦不大.

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

9. I will be under stress during the STEM workshop.

在 STEM 工作坊中，本人會感覺壓力.

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

10. I enjoy taking the course with STEM activities embedded.

本人喜歡就讀一些含有 STEM 活動的課程.

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

11. I am scared by STEM activities in this course.

本人對此課程內的 STEM 活動感到害怕

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

13. STEM activities can motivate and enhance my learning outcomes in the course.

STEM 活動能夠激發及加強本人於課程內之學習成果.

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

14. I will recommend my friends or colleagues to enroll in STEM-based training course.

本人會推薦朋友或同事去報讀含有 STEM 活動之訓練課程.

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

15. Overall speaking, STEM activities can enhance TVET for practitioners from the Fashion Textile and Clothing industry.

整體而言, STEM 活動能夠加強時裝紡織及服裝行業之從業員在職業教育與培訓的成果.

☐ Strongly disagree 絕對不同意

☐ Disagree 不同意

☐ Neutral 中立

☐ Agree 同意

☐ Strongly agree 絕對同意

Abbreviations 簡稱

STSC – Spare Time Study Center
業餘進修中心
STEM – Science, Technology, Engineering, Mathematics
科學,科技,工程,數學
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職業教育與培訓

End 完

Appendix D (Summary on Transcriptions)

-- Summary and findings from the FTC industry representatives

Section A-Fashion Textile and Clothing Industry (FTC Industry)

In **question one** which was asking the overview on the FTC industry in HKSAR, both FTC_01 and FTC_02 mentioned the FTC business and operation has been relocated from HKSAR to Mainland China, especially around the Greater Bay areas in recent years. FTC_02 also highlighted the industry mode has been changing to the trading mode, and a new retail direction called "New Retail" mode has been emerged. Therefore, it is better to work back from the retail endpoint in the supply chain. Similar response has been received from FTC_03 that the past mode of labor intensive production was changed and shifted to Mainland China and Offshores, trade business became dominant nowadays in HKSAR. However, FTC_04 mentioned that the FTC industry was lacking the right people with skillsets in production technology and quality control, whilst FTC_05 reported that HKSAR was mainly concentrating on design and merchandising sectors instead of textile business.

In **question two,** there are concerns about the current and future needs for quality and capacity of manpower in the FTC industry. Both FTC_01 and FTC_02 agreed to focus more training in marketing, e-Commerce and sales channels areas. As HKSAR was more competitive in data exchange and strong in design, the new retail mode e-Commerce and sales strategies required big data to support in order to approach international markets. Henceforth, the manpower strength should be emphasized in creative marketing with technical support as well as the new retail sector rather than traditional merchandising and production sectors. FTC_03 noticed there was more bias to theory and less skill practice in the local TVET. Whilst FTC_04 argued a balance should be emphasized among various sectors, although no more production in HKSAR, but design and technology were still required fundamental knowledge, skills and technology to backup, thus craft and technical foundation were the capacity needed in the manpower development. FTC_05 responded that the element of technology was a greater trend for all parties within the industry in the future. For instance, technologies on big data for marketing, body scanner for garment stores, and 3D CAD software for virtual design have been seen.

In **question three,** it was regarding the problem or deficiencies in the current in-service practitioners. Both FTC_01 and FTC_02 mentioned there existed a distant gap between practitioners and market knowhow and not familiar with the Mainland China. Therefore, training delivered to local designers should be embracing market sense and online sales behavior in addition to the design skill sets. FTC_03 also thought that the actual skills for problem solving exhibited by the practitioners was questionable and reiterated that practitioners and management people should need ground skill sets as basis. As such, more external training and actual practice on machineries for more in-depth learning was a must. FTC_04 and FTC_05 both agreed design and merchandising sectors required technology to backup, such as 2D and 3D CAD software. And FTU_04 reported that trade practitioners acted like a messenger, just passing information from customers to factories without reasonable judgement on the validity due to inadequate technical knowledge background. Same as designers, owing to limited technical knowledge, they could not foresee the difficulty that would happen in the production.

Section B – TVET and Professional Recognition in Hong Kong

In **question four** about the trend of TVET in the FTC industry, FTC_01, FTC_02 and FTC_03 were all thought that the trend of TVET should be geared with fundamental technical knowledge and skills or even have to be up-skilled to cover and support e-Commerce and retails, product development and production. FTC_03 reflected that nowadays, more graduates from TVET would like to go into the retail sector, and in fact, trainees from the retail sector possessed more product knowledge than ordinary people. Indeed, training ought to train people to be aware and avoid problems when they happen rather than to solve any problem upon happening. To achieve that ability, trainees have to be equipped with good fundamental technical knowledge to foresee and prevent a problem happening at an early phase.

As such, some corporates have set up their own knowledge archives known as "Knowledge Engineering" in which employees could shorten their time of learning by referring to the past cases recorded in the knowledge archives. However, it might still have a limitation, for example, people might query about whether the technology existed in an automatic Tee shirt production machinery line could be fully applied to all types of garments? FTC_03 foreseen that it would come true in the future. On the other hand, FTC_04 said the trend of TVET became weaker due to less support from Government of HKSAR, and most of the resources have been allocated to Universities that focusing in research projects. She reiterated that although there was no production in HKSAR, but skills and technologies were still required to communicate with overseas mills. She also supplemented that there was an inadequate resource to drive and push STEM elements in TVET. FTC_05 has also reflected that TVET was more stressed in the past years when compared to its presence. She borne the similar views as FTC_04 that the foundation training in TVET should be reinforced in the areas of design, merchandising and marketing. She agreed the enhancement in TVET was definitely the future trend, in particular, to kick off earlier for secondary school leavers who choose the vocational study route.

In **question five** are concerning the professional recognition of TVET in FTC industry. Basically, all of them realized the professional recognition on textile and clothing was not in order yet but already underway and in place soon. FTC_01 also said there was no standard recognition in fast fashion business. FTC_05 mentioned that the general public might not realize the importance of professional recognition due to insufficient publicity.

In **question six,** it was about the perspectives of industry representatives on TVET and TVET trainees in HKSAR. Different views regarding technological learning were collected from those representatives, like FTU_01 highlighted training on e-Commerce, online paper pattern manipulation as well as simulated 3D garment design, FTU_03 said designers are needed to be equipped with high content of technology which was similar to what FTC_04 and FTC_05 reported, in-service training could enhance trainees' knowledge and skillset, such as related training on new machineries, shoes knitting and seamless knitting machines that was definitely do good to the industry. Last but not least, FTC_02 wrapped it up by saying that TVET should be more sensitive and adaptive to the changing market as well as trainees needed to possess wills to develop in the textile and clothing industry.

In **question seven**, it was concerning about the acceptance of TVET by the general public and employers nowadays. FTC_01 and FTC_02 both agreed it was positively accepted by the industry, and trainees from TVET were equipped with strong ability on skillset and competence. However, FTC_03 responded that the acceptance of TVET would be pretty much depending on types of works. For instance, owing to the better English language ability and communication shown by people from HKSAR, hence they have a good potential to deal with US and EU customers. On the other hand, people from Mainland China possessed Russian language ability, and hence they could communicate with customers from Russia and those in the one belt one road countries. FTC_04 and FTC_05 committed that TVET was welcomed and highly accepted by the employers. Only FTC_04 mentioned many parents with a rooted mindset who thought TVET institutions were inferior to the local or overseas Universities.

<u>Section C-STEM Elements and Activities in TVET Curriculum</u>

In **question eight**, it was about the familiarization of STEM reflected by the industry representatives. Basically, FTC_01, FTC_02, FTC_03 and FTC_05 exhibited certain knowledge in STEM. Like FTC_01, claimed on top of science, technology and mathematics, more new elaboration on technology things for science might need, as technology consists of technical skills to sell things, engineering was rather a bit factual, and mathematics could be something like big data or further. FTC_02 mentioned STEM has largely existed in primary, secondary and tertiary education. Examples he cited were VM application for virtual project display and presentation, paper pattern grading by computer software system as well as 3D garment pattern and virtual fitting. FTC_03 claimed he was coming from a science background who was quite familiar with STEM. And FTC_05 supplemented that STEM commenced from secondary schools, and many people were longing for STEM. She knew clearly what “S” and “T” representing in the word STEM. Only FTC_04 replied that she did not have much knowledge about STEM.

In **question nine** regarding the TVET curriculum training focus and supporting facility, both FTC_01 and FTC_03 mentioned on 3D scenario through the computer, such as 3D virtual design and fitting, simulation on catwalk show, 3D CAD software, computer cutting bench and CAM system in which TVET was required to incorporate as training facilities similarly adopted in the industry, especially, the big data was all win in STEM. The reason was trainees could pick up the operation easily when working in the factories. FTC_02 also cited smart manufacturing, smart inventory and warehouse control and new retail mode which has already been practicing in Mainland China. Henceforth, besides training facilities which were similar to those in the industry, FTC_03 supplemented it was essential to include work-integrated learning (WIL) in the curriculum. In the past, that was called “sandwich” a course which was catering for working adults, they have to spend one full day in study and be released back to work for the remaining four days in order to secure an authentic practice experience. FTC_05 also echoed updating technologies and facilities which were important to cope with the courses. She mentioned the same 3D CAD software in design drawing and paper pattern design process. Furthermore, FTC_04 said the four elements in STEM were all vital for contemporary society, in particular, technical issues were important for different streams and curricula. And those four elements needed facilities to support, like laboratory to support science and data color system for training.

In **question ten**, opinions on exploration and the incorporation of STEM activities in TVET curriculum or courses have been collected from the five industry representatives. All of them committed to explore and incorporate the relevant STEM activities so as to increase the incentive and involvement of the trainees during the learning experience reiterated by FTC_01.

In **question eleven**, it was concerning the implementation of STEM activities in TVET curriculum or courses. Common views from most of the industry representatives were industry support and funding support from the Government of HKSAR to purchase hardware and software facilities as well as staff development for TVET instructors. For the implementation, FTC_02 reflected the importance of WIL and collaboration with industry in order to enhance trainees in authentic workplace learning experience that was similar to FTC_03 mentioned in coming trend, TVET seemed to have better chance to pair up with SMEs in providing training since large corporates might afford to set up their own training academy and run the training by themselves. However, FTC_04 quoted 人(instructor who know how to teach), 機(machineries and facilities), 物(enough material for practice), 法(methodology in delivery) which were highlighted by an industrialist in HKSAR for implementation, and also have to change the mindsets of general public on contemporary technologies which were totally different from the past

In **question twelve**, it was about the STEM knowledge level of TVET in HKSAR.

FTC_01 reported their STEM knowledge were just at a moderate level that might not be enough for future needs, especially, 3D software and big data were essential for the industry. However, FTC_02 was not quite clear about their background, but attention has been paid to China Huizhou on TVET. Trainers were requested to have at least three months of industrial attachment in an enterprise to acquire more new and down to earth knowledge for teaching. Many enterprises in Mainland China were willing to send out trainers for staff development. However, FTC_03 and FTC_05 reflected the opposite views, FTC_03 agreed that local trainers should have enough STEM knowledge and skills to teach whilst FTC_05 disagreed with that. But both of them have a common comment that due to too many new emerging knowledges in STEM, it might therefore need to outsource external suppliers or organizations who have that professionalism to play the role of teaching instead.

In **question thirteen**, it was mainly concerning the effectiveness of STEM activities in TVET which could benefit the sustainable industry since trainees would have deeper recognition after the training in STEM activities. Moreover, trainers could deliver the related and update skillset to trainees that helped the industry. Basically, all of them agreed that STEM activities in TVET could somehow benefit the industry. And sustainability in industry depended pretty much on how many new emerging technologies were replacing the old ones. FTC_05 responded that apart from research business, other industries also needed to know about STEM for efficient communication. For example, sales department made use of big data for analysis that helped in marketing and publicity, wearable technologies, 3D scanner for obtaining body measurements in wedding garment design and customization in production would be the trend thereon.

Section D-Relationship between TVET and Sustainable Industry

In **question fourteen**, industry representatives provided their views on the challenges that the FTC industry is facing in order to achieve environmental sustainability. In general, most of them gave similar views on how technologies could help in the environmental protection. FTC_01 said 3D simulation in weaving a fabric could save time, no emission, no transportation and logistics since no real fabric sample was being produced in the process. FTC_02 and FTC_05 mentioned Eco technology like waterless washing in denim, during the printing and dyeing processes which consumed negligible or even no water that was good in energy saving as well as carbon dioxide footprint control and discharge that was supposed to match with the concept of environmental sustainability. FTC_03 claimed that although there was no factory and production in HKSAR, but people have eco-friendly materials and process to work on, and STEM knowledge background was good to justify with reality. Moreover, FTC_04 has pointed out the challenge in costing about the recycling process on air, water and solid wastes, which was still a vital issue. Technology would still need to be advanced to lower down those recycling costs. FTC_05 supplemented that fast fashion wasted a lot of resources, and nowadays, people should be reminded to purchase less and discard less to avoid adding burden to the earth.

In **question fifteen**, it was concerning about whether TVET had a high value in providing feeders to a sustainable FTC industry. All the industry representatives agreed to that with the following supplement. FTC_02 reiterated the provision of human resources should meet the fast changing market. FTU_03 replied that the skills content of people from industry was still low although they were the feeders to them. They might not able to spot out and tackle the problem efficiently. What industry demanded was problem prevention rather than problem solving, henceforth, STEM knowledge was important for accomplishment. FTC_04 supplemented she encountered a Spanish company named Jeanologia during her recent business trip to Barcelona, Spain. That company was focusing on Eco-process development, such as treatment of waste water. And Jeanologia was willing to offer industrial attachment for an authentic workplace learning experience for overseas trainees from Shanghai. She said it was also good for TVET graduates from HKSAR as feeders to the niche technology for the industry. FTC_05 wrapped it up by saying industries normally relied on TVET to provide successors to them.

In **question sixteen**, it was asking about the elements in TVET for a sustainable industry. FTC_01 raised the mode of survival in industry has to be matched with the ways of 衣, 食, 住, 行 in which big data would be the underneath support. FTC_02 reflected the TVET should include the ethics and compliance in the environmental sustainability for training. Besides what FTC_02 mentioned, FTC_03 supplemented the trainees should also consider to realize the cultural sustainability apart from environmental sustainability, and ethical problem on wealthy and poverty, child labor, goods production inside prison. FTC_04 reported STEM was essential elements in TVET since it would help sustainability to a certain extend upon trainees attended on the job training. Lastly, FTC_05 pointed out Eco-concept was required in printing and dyeing, and cited a realistic example of recycling project collaborated amongst HKRITA, H&M and The Mills. As most of people understood the garments were involving quite a lot of printing and dyeing processes, that project was done inside forty feet movable container which could turn the old and used garment to the new one via the deconstruction, re-design and reconstruction procedures around seven hours. That could be practiced at anytime and anywhere with less limitation.

In **question seventeen**, it was relating to the linkage amongst STEM, TVET and SD in the industry. All of the industry representatives agreed there was close linkage amongst the three aspects. FTC_01 raised the 3D printing technology that could print out product directly and no need to cut down trees to generate fibers and yarns for fabric weaving as well as STEM in 3D simulation of fabric to save up lead time with less real fabric weaving and production. FTC_02 also pointed out STEM acted as a tool in teaching methodology to arouse trainees' creativity. While FTC_03 and FTC_04 mentioned STEM together with TVET made the SD work and bloom or TVET should encompass STEM as well as SD so as to benefit the industry.

In **question eighteen**, trainees' learning attitudes in TVET with STEM activities embedded were solicited from the industry representatives. Generally, reflection from those representatives were good, satisfactory and positive. Especially, FTC_02 and FTC_04 both said the learning attitudes from part-time or in-service trainees were better as they have interest to acquire new thoughts and methods during learning with STEM activities embedded. In addition, FTC_03 supplemented most of the trainees accepted and appreciated the dynamic approach in STEM activities that allowed them to concentrate more resulted in better retention in class eventually. Besides welcoming by trainees, FTC_05 pointed out STEM activities could enlighten trainees in learning or even with better effect if trainees could get in touch with STEM earlier at secondary school.

In **question nineteen**, regarding industry representatives' views on skills and competence of trainees in mapping with the industry, FTC_01 and FTC_02 both mentioned not all trainees could map into the industry, and there was a science and technological gap existed among generations as well as lacking practical experience in workplaces to fulfil the demand from market. Indeed, more proactive jobs and sales models were required to replace those old and boring works. FTC_03 and FTC_05 agreed their skills and competence were basically mapped to the industry in principle. However, TVET should provide trainees with crystal clear on real scenario and operation which matched with the industry to avoid any misunderstanding and false expectation from them. Furthermore, FTC_04 reported trainees from VTC were more practical than those from HK PolyU, they were willing to take up hands on job in lower rank. Upon the recent bloom in STEM, their skills could somehow fill up the gap and map into the industry. In fact, there were various kinds and levels of jobs, people have to keep themselves up in the lifelong learning route so as to stay abreast. A non-stop study pathway from technical knowledge to production knowhow and eventually to management level.

In **question twenty**, it was about the employability and mobility of practitioners from TVET in the industry. FTC_01 and FTC_02 responded that employability and mobility in HKSAR was moderate compared to the greater bay areas in Mainland China due to the diminishing investment from companies in HKSAR. FTC_01 highlighted the e-Commerce model trained up by Alibaba was highly acceptable in Mainland China. Similarly, FTC_04 pointed out both the employability and mobility were fine, in particular, the upward mobility depended pretty much on employees' solid performance as well as related further study. In vertical mobility, FTC_03 stressed that although skill sets helped in the authentic workplace, but promotion to higher ranks still required the employees to demonstrate enough experience together with management ability. He supplemented that head hunting activities could always be noticed among enterprises. As such, employability and mobility were all the times subject to the skill sets and aggressiveness of the employees. Another mobility FTC_03 mentioned was the willingness of employees to work abroad. That's why some chambers in HKSAR encouraged minorities here to travel and move back to their own countries and acted as bridge in communication due to their appropriate language proficiency in offshore countries, like Bangladesh. FTC_05 echoed that although industries in HKSAR were downsizing and relocating to Mainland China as well as Offshores, there still had demand in the retailing, design and merchandising sectors, and promotion was still needed business management knowledge and operational experience.

In **question twenty-one** that related to employers' satisfaction with current practitioners' skill level and depth. Basically, FTC_02, FTC_03 and FTC_05 said their fundamental skill sets were enough and satisfactory, and also depended upon their working attitudes, dedication to job as well as their actual ability in the workplace. One concern from FTC_05 was practitioners' mind sets to cope with the development in the corporate and any communication gap existed across different departments, such as design and merchandising departments. Only FTC_01 reflected that the satisfaction from employers was just moderate due to incomprehensive training at school. He stressed the training should be more vibrant with flexible application in the workplace rather than factual instruction. The key thing was to teach trainees how to learn in the ever-changing market and environment.

In **question twenty-two**, new ideas for TVET are being developed and advance. FTC_01 and FTC_03 reiterated technologies were playing an essential role which were embraced but not limited to the new application of computer software for body measurements, automation through robots and artificial intelligence in workplaces. However, FTC_04 and FTC_05 were emphasizing more on the content of delivery in TVET that should map to the industry and the incorporation of work integrated learning (WIL) which was similar to the "sandwich" course in the past years. A sparkling idea raised by FTC_02 was to focus on the retail ends, then work backward from the customer market to the sourcing origin. Attention could be pay more in Mainland China and S.E. Asian countries.

In **question twenty-three**, the author wanted to find out any negative impact from TVET received from the industry. Except FTC_03, all of the industry representatives reflected that there was no negative impact received from the industry so far. And FTC_03 has only expressed that the income adjustment of workers was not going on pace with the market whilst FTC_04 supplemented that TVET received less support from parents.

In **question twenty-four**, that was about whether STEM activities would be able to enhance trainees from TVET in knowledge and skill competence basis to meet the challenging sustainable industry in the 21st Century. All the industry agreed it was positive since trainees from TVET received actual practical training, participation and an authentic application to meet the sustainable industry. In addition, FTC_04 highlighted the importance of the provision of update and down to earth STEM resources.

In **question twenty-five**, the author was wrapping up the interview by asking them if any important information has been missed out during the survey. FTC_02 said TVET should prepare the trainees to reach out to other markets which were more diversified and potential in development. And consider the demands from other countries due to the limited prospect seen in HKSAR. Finally, FTC_03 pointed out the Government of HKSAR should support and take role in the STEM elements in TVET in order to meet the challenging sustainable industry in the 21st Century.

---Summary and findings from FTC trainers and instructors

<u>Section A-Implementation of STEM-based activity in TVET</u>

In **question one**, it was mainly to collect the overviews of trainers for the implementation of STEM activities in TVET. TRR_01 pointed out several methods for implementation. Many practical workshops were equipped with machineries, trainees could operate them with the theory support in behind. Moreover, chemical science like textile printing and dyeing, engineering like fabric structure and construction, mathematics like calculation in textiles, all those required trainees to carry out an experiment by using a microscope, burning test or chemical test under the STEM activities to differentiate various types of fibers and their natures. TRR_02 responded that it was quite new and creative to combine and infuse STEM with 3D CAD software. TRR_03 and TRR_04 agreed STEM activities were good for trainees, as they could receive actual practice instead of merely theory instruction. During the practical workshop, they could dig out the problems, looking for feasible solution to enhance their understanding in learning experience.

In **question 2**, it was regarding how to implement the STEM activities. TRR_01 reiterated that the implementation must be worked hand-in-hand with the industry since the new things development was much faster occurred in the industry than TVET. And trainees could learn through social media and YouTube videos. An example of a VR project collaborated with industry was cited by TRR_01 for interactive and interesting learning in textile processing. As trainees seldom got a chance to visit cotton fields or organic farms in north west China such as 新疆, therefore, VR experience was essential to encourage and enhance trainees in the understanding of spinning, dyeing, weaving, finishing on yarns, fabrics and accessories. The implementation involved various parties in different role plays in the STEM activities for learning. Textile instructors provided relevant knowledge and context, IT engineers were responsible for writing program, industry helped to align site visit for photo and video recording, and finally the whole process could be explained to the in-house trainees in an animated presentation without limitation on time, venue, as well as safety issue concerned.

TRR_02 reported that nowadays, trainees could be taught and use 3D CAD software to replace the traditional hands-on method to draw paper pattern, cutting of fabric as well as sewing a garment. All those could be done from virtual design, virtual paper pattern manipulation, virtual sewing and eventually virtual fitting on an avatar on the computer for immediate sharing and discussion. TRR_03 highlighted STEM activities should be occupied around two thirds of a training course in which trainees were requested to provide feedback or conclusion on what they have learnt, and see whether the expected outcome could be attained or not. TRR_04 said it was helpful to implement the demonstration on hands-on works and coach trainees in the workshop practice as well as leading them in a factory visit that would enable them to experience and understand more about the authentic operation in the workplace

In **question three**, trainers were reporting the difficulties and or constraints encountered during implementation. With reference to the VR project, TRR_01 said the limitation was coming from support from top management on extra manning and funding resources, as well as the coordination among interdisciplinary staff so as to arrive at a mutual benefit and win-win situation. TRR_02 reported the limitation was mainly in the computer software, since all the virtual processes were set inside the computer, once the computer software failed to work, all the tasks would then cease.

Moreover, trainees could not smell and touch the virtual fabrics and hence lack of tactile feeling on real textiles. Lastly, TRR_03 and TRR_04 mentioned similar limitation on inadequate facilities and resources on a trainer, as one trainer might not be able to look after a large group of trainees in the practical workshop.

In **question four**, trainers were being asked how to overcome the difficulties and constraints aforementioned. TRR_01reiterate top management has to get involved and provide strong support together with professional knowledge from the working parties. TRR_02 replied that 3D CAD software actually got a functional icon to apply handy pull (by using the mouse) on the virtual fabric to observe the drape of it. TRR_03 mentioned instructors from industry could bring the trainees to visit factories, fashion fairs and companies in order to widen their visions. Also, in-service trainees from different backgrounds of design and merchandising could share new ideas and interact among themselves to overcome the shortage of facilities during training. TRR_04 suggested hiring more workshop assistants and dividing large class into small groups during the delivery. He supplemented that one would be the physical group, while the other group would then be in e-learning mode. However, it was not an ideal solution as trainees in the e-learning mode would lack of real practice and interaction among trainers as well as themselves.

In **question five,** it was concerning about the resources and facilities required for full implementation. TRR_01 responded that many machineries, manpower, computer facilities and funding were needed in the VR project. As all those machineries and facilities were distributed across various disciplines, henceforth, good sharing and cooperation was required in the full implementation that solved the limitation in location. TRR_02 reported 3D software, funding and sponsorship as well as computer facilities in the computer room together with paper pattern tools and sewing machines were required for full implementation. TRR_03 highlighted the full implementation should involve interaction with industry for new machineries purchase as well as funding support. Also, trainees could go back to use those facilities upon graduation and keep the optimal utilization thereon. Because small brand or individual designers might encounter difficulty in purchasing too many expensive machineries such as, laser printer and so on, therefore TVET should consider to support them. TRR_04 mentioned solid teaching materials, realistic machineries and hardware which were vital for implementation to enhance trainees learning and understanding in conducting STEM activities during the training course.

In **question six**, it was about how to incorporate those resources and facilities as well as the cost concerned. TRR_01 and TRR_02 provided similar views on how enough room and space have to be prepared to house facilities like computers and related tools, TRR_01 supplemented that funding and advice should be sought from industry to purchase up-to-date facilities, and the total cost incurred might be very high. Whilst TRR_03 and TRR_04 gave similar comments about training facilities, they should be provided by training institutes, because a small company usually could not afford those expensive facilities due to the cost and limited space concerned. So, the training institutes should incorporate facilities for long term purpose as well as sustainable needs which enable trainees to use them frequently thereafter. And sometimes, it was hardly enough to breakdown the overall costing.

In **question seven**, trainers were being asked about the learning attitude and receptivity of trainees during the workshop embedded with the STEM activities. Basically, all of them reflected that trainees accept the STEM activities with interest and positive learning attitude. TRR_01 recalled her experience in the VR project, trainees demonstrated interest and good learning attitude in the STEM workshop and fond of hands-on practical exercise and authentic experience during participation which embraced factory visit, laboratory experiment and VR experience for learning enhancement. TRR_02 reflected trainees exhibited great interest, receptivity and good attitude to try and learn and their works were creative. TRR_03 and TRR_04 both pointed out trainees or practitioners from industry accepted STEM activities and able to feedback what have been learnt in practical hands-on workshop as well as actual experience along the learning process.

In **question eight**, it was concerning about the overall participation of trainees in the workshop. All of the trainers agreed trainees normally demonstrated good participation in the workshop because they felt interest and afresh about the guided exciting activities.

In **question nine**, trainers' views on trainees learning outcomes including knowledge, skills, and attitude in STEM were solicited. All of the trainers were showing positive sign toward the question. TRR_01 supplemented that industry involvement could let trainees know more about the application of knowledge in real situation. For instance, designers from industry could provide feedback and comment on trainees' works so as to meet the industry demand and attain a good outcome. TRR_02 and TRR_03 said their attitudes were fine, more constructive and really enjoyed the learning experience that deepened their memory. And agreed STEM activities were vital and necessary for upskilling. Finally, TRR_04 reported an increment and improvement on relevant outcome embracing knowledge and skills in STEM.

In **question ten**, it was about the effectiveness of STEM activities embedded in TVET course for the FTC industry. In general, all of the trainers agreed that was fine and effective for trainees to acquire up-to-date knowledge during practical training, testing, strengthened up the confidence as well as hands-on crafts that matched with the expectation from industry. And TVET needed to work closely with the industry. Meanwhile, TRR_02 raised out that STEM activities were fine to short courses lasted for a few days, in view of long term running on all round training, both theory and STEM activities should be in place. Perhaps more theory part could be considered for industry practitioners, whilst focus more on STEM activities for students from secondary schools which could definitely arouse their interest in learning since they did not have much knowledge about industry. Last but not least, TRR_03 supplemented there was sometimes a mixture of trainees from different countries attended the in-service training, they would share out their learning experience on factory and fashion fair visits during peer group learning. Based on her past experience, she wrapped up by saying that trainees would rather like to listen to the jiggling sound of machines instead of the boring tones from the instructors!

In **question eleven**, it was asking about any new idea for STEM-based activity to develop. TRR_01 mentioned multi-disciplinary collaboration was essential, like in VR project, engineering students worked with IT students in co-braining and co-learning along the entire process. She also raised mobile gamification could also motivate students to learn fashion and textile. For instance, an AR program on goat trapping, students could learn about different species of goats as well as their wool type characteristics in a vivid learning atmosphere. TRR_02 replied a virtual fashion design competition could be organized and inviting secondary school students to participate by adopting the 3D CAD software design and realized by an avatar on virtual catwalk show followed by voting online for winner. TRR_04 mentioned about the laser washing method (by using less water) on denim was a common topic in sustainable industry development. TRR_03 has recalled a well preparation before lesson by both instructors and trainees was important, like video viewing and YouTube might help the workshop efficiently. Of course, industry input would definitely keep trainees abreast in the industry.

In **question twelve**, it was trying to collect any negative impact from STEM activities. Basically, there was no negative report received from TRR_01, TRR_02 and TRR_04. However, TRR_01 and TRR_02 both reiterated relevant supports, adequate resources and industry collaboration was important to drive STEM activities in the learning process. And TRR_03 raised out there were two types of trainees, one was initiative and strong whilst the other was slow and reluctant in learning. As such, attention was required to engage both of them during the workshop delivery. Only TRR_04 mentioned the cost of STEM activities, which would be an issue to consider.

In **question thirteen**, it was asking whether or not STEM activities would be able to enhance trainees from TVET's knowledge and skill competence basis to meet the challenging sustainable industry in the 21^{st} Century. In general, all instructors/ trainers agreed and supplemented with positive comments. TRR_01 said fashion design students ought to learn science, materials' nature as well as chemistry in order to understand the dyeing process in textiles. TRR_02 believed that 3D software was new and vital in the trend, and many garment companies would adopt this soon.

In **question fourteen**, instructors/ trainers were asked if any important information was missed out during the interviews. TRR_01 responded that STEM activities needed to be defined, understood and committed and focused on project-based learning which allowed trainees to try, experiment, and apply the knowledge acquired that was totally different in the past (only instructional PowerPoint and craft oriented learning). TRR_03 mentioned more hands-on works or trainees exchanged with other countries to broaden the scope of vision on new things in the world. Lastly, TRR_04 claimed to have more synergy with industry, training courses could be opened to the general public like people from the business field to fill up the gap. Also, TVET should pay more attention to the market needs, customer pool and drive the garment technology courses thereon.

--- Summary and findings from FTC trainees

In **question one**, it was concerning whether trainees thought STEM activities were useful or not in TVET and the reason behind. In general, all the seven interviewees agreed positively and helpful to certain degrees. TRE_01 highlighted it could enable them to learn heat conductive products and recognized the function and working mechanism behind. TRE_02 responded that she could see more new things which would benefit the corporates. TRE_03 reflected there was good experience on interaction amongst trainees. TRE_04 confessed that he had more in-depth understanding on how heat conductive technologies worked in the real situation. TRE_05 knew about the new change in the technology that was good for buyers or technicians who were dealing with many materials and things. TRE_06 supplemented the learning content, which could enrich his knowledge. TRE_07 recalled the workshop and how STEM activities could enhance their learning impression as well as understanding on waterproofness and breathability in wool. She agreed the STEM workshop was necessary.

In **question 2**, it was about trainees' thought whether STEM activities were interesting or not and the reason behind. Basically, all the interviewees gave positive feedbacks. Like TRE_01 mentioned, similar courses with real product demonstration and allowed trainees to try and experience it would definitely arrive a good result. TRE_02 said she could apply what has been learnt in the STEM workshop in the daily life. Whilst, TRE_03 said the STEM activities were playful and enjoyable. TRE_04 agreed it could enhance their understanding in technology on how heat generated from products and further application with a more explicit view. TRE_05 said the workshop was comprised of vivid STEM activities that enrich their understanding upon trying and experiencing instead of merely listening to the class. TRE_06 reported the on-site demonstration was very interesting, and TRE_07 encouraged and supported STEM activities in the contemporary education.

In **question three**, it was regarding whether trainees like to participate in STEM activities or not and the reason behind. Generally, all of them rendered positive responses. TRE_01 and TRE_03 loved the course embedded with STEM activities and felt good during the practice and experience in the authentic learning process and application. TRE_02 and TRE_04 said it allowed them to understand more new technology for self-upgrading in the modern society and useful for jobs. TRE_05 reported that she wanted to learn new things and technology. TRE_07 also responded that she and her friend were fond of the STEM activities which enabled them to share those knowledge with their colleagues when they were back to office. However, although the STEM method was good enough to increase his interest during participation, but it would depend on the relevancy between the workshop topic and the job to determine whether it was helpful or not.

In **question four**, interviewees were asked about any problem or difficulty encountered during their participation and the reason behind it. All of the trainee representatives reported not many to no difficulty encountered. The course was good and professional, the delivery was clear with detail elaboration on new information about heat conductive products and easy to master during the workshop, and a lot of queries could be resolved through STEM activities. Also, TRE_07 supplement the workshop was simple and direct, the instructor was able to explain explicitly, instruct and coach them by the side during the demonstration as well as activities.

In **question five**, it was concerning about the receptivity of STEM activities in TVET courses. TRE_01, TRE_02, TRE_05 and TRE_07 showed high receptivity and happiness in it. That was also moving at the same pace in the modern industry and beneficiary to their works.

TRE_05 said they were eager to visit a factory with innovative technologies as well. TRE_06 appreciated the teaching method which involved the application, vivid and vibrant that in the workshop.

In **question six**, interviewees were expressing their expected learning outcome before participating in the TVET embedded with STEM activities. TRE_01 and TRE_03 did not have much expectation before joining the workshop. While TRE_02 wanted to collect information on STEM for self-upgrading. TRE_04 and TRE_05 expect to know more new things and deeper understanding of new technologies. TRE_06 expected to select a topic matched with the job directly, and he confessed he had interest during participation. However, TRE_07 reflected that she did not know it was a STEM workshop and just thought it was an ordinary lecture with PowerPoint and handouts.

In **question seven**, interviewees were reporting whether the course and STEM activities met their expectation or not. TRE_01, TRE_02, TRE_03, TRE_04 and TRE_05 all answered positively and were willing to share what they had learnt in the workshop when they came back to the office as it could help them when handling raw materials, purchasing and application when coming across those types of heat conductive products in their jobs. TRE_06 responded that it was fine, and he could learn some new knowledge on new function, new technology about wool after joining the demonstration and STEM activities with satisfaction. Same as TRE_07, her expectation was satisfied.

In **question eight**, it was about the overall effectiveness of the STEM workshop. All of the seven interviewees agreed it was effective and got something solid on new things. TRE_01 would like to have a longer period of time in STEM activities in the future to practice and experience the real products for sharing and discussion. TRE_06 and TRE_07 both said it could help them in the functional knowledge and enhance the understanding and application of the job as well as other new products development to customers afterward.

In **question nine**, it was aiming to solicit any new idea from trainees for a STEM-based activity to develop and the reason behind. TRE_01 and TRE_05 reported quite similarly that it would be better to prepare the heat conductive products in semi-finished parts or deconstructed cross sections to show the inner working mechanism, so that they could involve in assembling the products that clearly knew how fabric, electrical wires and power bank worked together for heat generation and control as a whole, as such, they could convey an explicit picture to their colleagues when back to the company. TRE_04 said that if possible, activities would be better to arrange in a training center which has more advanced facilities and laboratory equipment for better learning and experiencing. Lastly, TRE_02, TRE_03, TRE_06 and TRE_07 all have no comment in return.

In **question ten**, it was about any areas or aspects for improvement on STEM activities collected from interviewees. TRE_01 and TRE_05 both mentioned better to have semi deconstructed or dismantled garment parts and samples to demonstrate the inner parts mechanism in order to enrich the learning content with details, and it is also good to have more time for practice as well as hands-on works so as to benefit trainees' absorbing power and understanding during the STEM activities. TRE_02 wanted to have more courses with up-to-date information for continuous feedback and improvement. And TRE_04 recommended the training venue to be equipped with more facilities to support and enhance trainees' understanding. Perhaps intermediate courses could be organized to explain more details on how battery and sensors worked together in the near future. Whilst TRE_06 mentioned more topic areas, more topics could be considered and try to cover more raw materials. Since trainees from the textile and clothing industry might get in touch with many raw materials related to outdoor sports, fashion, streetwear, etc. Therefore, a wider spectrum of topics or raw materials was preferred for sharing. TRE_07 suggested more STEM activities and longer duration could be considered next time, as the last workshop seemed a bit hurry. Only TRE_03 has no idea of returning as STEM activities were fresh to her.

In **question eleven**, all interviewees were asked whether or not the STEM activities could be able to enhance their knowledge and skill competence basis to meet the challenging sustainable industry in the 21st Century. All of them agreed it was helpful and positive to the sustainable industry.

In **question twelve**, interviewees have been asked if any important information missed out during the interviews that they would like to comment on. Only TRE_07 said she did not know it was STEM before participation, just thought of an ordinary workshop. No additional comment was received from the rest of them.

Appendix E (Transcriptions on Focus Groups Interviews)

Section 1. Focus group of FTC industry representatives

Section A – Fashion Textile and Clothing Industry (FTC Industry)

In the **question 1**, interviewees were asked about their overviews for the FTC industry in Hong Kong, and below were their responses.

- FTC_01 reflected that almost all textile and clothing manufacturers and business have been relocated to mainland China, especially in the greater bay areas, the operational scale in HKSAR has been reduced. Most of the ground shops in Sham Shui Po selling textile related products have been relocated to the upper storey for operation.
- FTC_02 mentioned that the fashion and clothing industry in Hong Kong has entered a changing phase from industry mode to trading mode. In particular, in mainland China, a new retail direction has been emerged, and FTC_02 called it a new retailing mode. How to satisfy the contemporary market needs, it required more works from the FTC industry in the future and has to work back from the retail's end-point in the supply chain. That was, from retail

sales backward to the manufacture and then back to the product design and development stages.

• FTC_03 reported that the past practice of labor intensive production has been changing, like from OEM to ODM to OBM, various performance was observed from different corporates. Anyway, trade business became dominant nowadays, whereas production has been shifted to either mainland China or offshores. In the meantime, product development was still concentrating in HKSAR and greater bay areas, but owing to the trade war happened between the US and mainland China, the China factories would keep on moving out to offshores as well as Africa, or even many more farther regions in the world. Then FTC_03 queried whether the skill sets from HKSAR still enough to cover or people in HKSAR willing to migrate and stay in offshore factories to work in which a cultural difference was a big consideration.

• FTC_04 reiterated that the industry was lacking of the right people with skill sets in the areas of production technology and quality control. A bias focus has been seen in the design and trade sectors. Actually, basic technical skills could not be missed out in the foundation, the FTC industry lacked of technical and skillful workers who had received inadequate skill sets training. Indeed, the Vocational Training Council (VTC) might be better than other universities such as HK PolyU had no technical element in their curriculum and also didn't know why there was no practical workshop as well.

• FTC_05 said that there was basically no more textile business in HKSAR nowadays, the society was mainly concentrating on design and merchandising sectors.

In the **question 2**, interviewees were asked about the current and future needs for the quality and capacity of manpower in the FTC industry, and below were their responses.

• FTC_01 claimed that HKSAR needed to be trained more in the marketing area, sales channels should have more support and promotion to achieve a business goal. As there was an update on the technology, sales channels were all different and changed from the past. Nowadays, customers seldom visited the physical trade fair, they would rather go online. As such, online channel required certain skills to entertain those customers, which obviously was a market niche to the industry. Also, there was a great competition in marketing and promotion areas. Online platforms could proactively or passively post some news for customers without limitation on timing and venue. For instance, there was a lot of preparation and follow-up work for a traditional fashion show which only lasted for seven days. But the online platform could somehow require one day to answer inquiries and complete the order. FTC_01 realized that successful people might come from the FTC industry whom were the other interesting parties. Regarding the manpower needs, FTC_01 mentioned the market needed creative and marketing people instead, and of course, there also needed technical support to allow a smooth business operation.

• FTC_02 said that under the fashion and textile environment in HKSAR, there need not to spend too much time in merchandising and production manpower areas. The reason was the global trend of self-localization in production, for example, it has been seen in mainland China. HKSAR was more competitive in data exchange and international scope of vision, also strong in design together with new sales strategies which required big data to support. One part in the new retail mode was e-Commerce in which HKSAR was quite slow in development. Designer from mainland China created their own brand using the e-Commerce platform to approach the international markets. Technological research in the academy was also a future direction. Since the mainland China was strong in textiles already, HKSAR should pay more attention to the strength of manpower provision in the greater bay areas. It should be focused on design and new retail manpower strengths who have the ability to adopt big data analysis and are well familiarized with the industry and no more need to stress so much on traditional merchandising.

• FTC_03 reported that people in HKSAR possessed English language advantage when compared to people from mainland China in regard to trading. Within the international city of HKSAR, they were more familiar with the deal, request as well as cultures with US and EU customers. However, mainland China was improving at a fast pace, and the gap between us was becoming narrower in textile and clothing production technology. Graduates from TVET in HKSAR usually could not adapt to the environment and pursued the job automatically, as a result, the employers have to provide in-service training to them, which was oppositely seen from the graduates ten years ago. Moreover, the skills contents of graduates from TVET were totally different from the past training in Hong Kong Polytechnics. Nowadays, more biased to theory basis and less skill practice was noticed in HKSAR, and that was quite similar observed in mainland China even though people in China were more aggressive than people in HKSAR. For the in-service practitioners from mainland China, their skill contents might be better than those in HKSAR. Therefore, the TVET in HKSAR should enhance the skill contents to enable them to reach out for production follow-up. As such, skills and technologies should be the prime focus in near future.

• FTC_04 argued that a balance should be held among various sectors although there was no production in HKSAR, but design and trade sectors still required basic knowledge of skills and technology to backup, thus basic training on skill sets when doing design or in trade was a must in order to communicate with customers on a persuasive ground. Without craft and technical foundation, customers could not be led confidently nor provide a quality service that ended up in a weak capacity.

• FTC_05 said that current TVET in HKSAR was mainly concentrating on three areas such as, design, merchandising and marketing. Of course, design encompassed paper patterning, production and operation. In future, to add in the element of technologies, there was a greater trend which was supposed to be done by every party within the industry.

Therefore, the same in fashion field, for examples, marketing sectors introduced big data element for more understand of the needs from end customers, stores introduced custom made element like body scanner to obtain body measurements for tailor-made clothes, fashion accessories like eye glasses, rings and shoes could also incorporate this element of customization as nowadays customers tended to go for more personalized characters. Just to supplement, in the design aspect, paper pattern worked through 2D computer software and 3D CAD software for virtual design has been seen.

In the **question 3**, interviewees were asked about any problem or deficiencies in the current in-service practitioners, and below were their responses.

• FTC_01 claimed that the main problem was the existence of a distance from the market. The old practice might not be updated as well as a gap happened in the market knowhow and pace.

• FTC_02 replied that designers were not familiar with the mainland China market, so when training is delivered to designers in HKSAR, market sense in China has to be trained in addition to design skills which embraced online sales behavior. In the merchandising field, there is no more huge order quantity instead of small and quick responsive order that talking about 200 to 300 pieces per style which needed to be delivered within two weeks. As such, in the future trend and needs in merchandising, fast order in the supply chain from sourcing to logistics was highly supported.

• FTC_03 mentioned practitioners from 20 to 30 years ago, their first job might last longer than a year. However nowadays practitioners frequently changed their jobs which seldom lasted for 2 years. Even though they could have more visions compared to the past, but actual skill sets for problem solving was really questionable.

Rather, the practitioners should possess a good ground of skills and the same as management people who also needed ground skill sets as basis. In view of that, more external training should be required. HK PolyU has set up many online courses which will provide flexibility very soon, but of course, they have to attend physical class with actual practice on machineries, so as to have more in-depth learning.

- FTC_04 said the deficiencies had been mentioned earlier. Trade practitioner and merchandiser acted like a messenger only, just passed information and words from customers to factories without any reasonable judgement whether those information were right or wrong owing to inadequate technical knowledge that created a drawback. Same happened in the design aspect, due to lack of technical knowledge, designers couldn't foresee their design would encounter any difficulty during production, any consequence in cost increment as well as effectiveness that also created insufficiency.

- FTC_05 highlighted that the overall trend was still around technology elements. All sectors in the industry were facing great impact and changes. Henceforth, design and merchandising should need technology to be a backup. For instance, automation in production, especially, fabric dyeing process, required more technologies to cope with the environmental protection concept. Same as design, it also needed 2D and 3D CAD software in order to arrive effective outcomes.

Section B– TVET and Professional Recognition in Hong Kong

In the **question 4**, interviewees were asked about the trend of TVET in the FTC industry, and below were their responses.

- FTC_01 responded that trade was the foundation for industry in which technical knowhow was a must! And TVET could spend more on the technical knowhow so as to support the business thereon. Perhaps universities might not be so technical as to cover all areas, but anyway, future trends should try hard to support technologies in trade.

- FTC_02 reiterated the market in HKSAR was too small, so training and backup should not only be in fundamental knowledge and skills, rather it should be up-skilled. More training on sales and retail should be conducted, not only just online sales, but also operation in a physical shop about how to manage sales and inventory keeping within a physical shop. Overall, it was to enhance retail training together with e-Commerce linkup.

• FTC_03 reported that there were two ways. The first way was the product development and production, whilst the second was the retail. In the current trend, more graduates were found to have interest in going to the retail sector. Indeed, trainees in the retail line should possess more product knowledge than ordinary people or other students. In fact, a large company was willing to hire people with good language and communication ability to work with their customers. Training ought to train people how to be aware and avoid problems when they happen rather than to solve problem upon happened.

They have to be equipped with good fundamental technical knowledge to foresee and prevent problems from happening in an early stage. In-service training was going to be the trend. Due to practical learning needs, some corporates have set up their own knowledge archive (known as knowledge engineering) which is full of past records of problems for hands-on reference. Colleagues could access that knowledge archive when they encountered new problems for reference and advice so as to shorten their time of learning. However, it seemed the cost of that knowledge archive was quite high.

Moreover, HK PolyU has offered relevant course to enhance the automation in production technology and product development, but the learners needed to possess certain technical knowledge background. An example cited was a US manufacturer buying a Tee shirt automatic production line and swapping the production locally in the US. Many people asked whether or not this model and technology could be applied to all types of garment. I have foreseen that it could not be done within five years and might happen in the future.

• FTC_04 thought the trend in TVET became weaker due to less support from the Government in HKSAR. Rich resources have been allocated to Universities which mainly focused on research instead of teaching, and resources on technology and craft training were not enough. In fact, they could not meet both ends, neither ability on research nor craft skill level. Actually, it should not be biased to the upper workforce level, since the middle to lower workforce level was the level and people took up the craft works. Universities have to make balance on the research and teaching aspects in order to balance the necessary workforces. FTC_04 mentioned TVET and VTC did not receive many resources from the Government of HKSAR. Although there was no production in HKSAR, but skills and technologies were still required to communicate with overseas factories efficiently. Furthermore, a design sector also demanded technologies to support and operate, like drawing paper pattern, computer software to assist pattern design, cutting and fitting, users have to know how to do and what would be the problems and risks and so on. Since not many people chose the articulation route to Universities, as such, it should be more focused on TVET, FTC_04 thought STEM elements were inside TVET. However, there were not adequate resources to drive and push forward.

- FTC_05 said that TVET should become more and more important. In fact, it was important in the past compared to now, the reason might be due to the migration of factories to outbound that made TVET weak. We needed to reinforce TVET, no matter in design, merchandising or marketing areas. If we still had the lack of foundation training, then it was difficult to drive on together with no good outcomes. Henceforth, to enhance TVET was a definite future trend, in particular, catering for secondary school learners who have interest and then providing them with some relevant trade specific short courses as earlier as possible for appreciation.

In the **question 5**, interviewees were asked whether or not they knew any professional recognition of TVET in the FTC industry, and below were their responses.

- FTC_01 replied that there has difficulty in technical assessment, for example, how to determine a good or bad paper pattern and render a grade to that, since it involved human factors like years of experience to do the paper pattern, subjective judgement on aesthetics and so on. Same as in design, which was difficult to judge good or bad. Therefore, it was hard to certify, rather it was likely to identify the minimum qualification. However, in buying and selling, it was easy to use some factual knowledge to judge good or poor. For instance, a good sample order or a tech-pack has been revealed in brand Zara, in which photo simulation is revealed in just only two pages. In fast fashion business, sample orders sheet requirement changed frequently and varied from details to simple information that has no standard recognition.

• FTU_02 said there is no professional recognition on textile and clothing under TVET, employers have to see people's actual experience other than what they have acquired in school. Indeed, HKSAR has built up qualifications framework in various trades, and an objective Specification of Competence Standards (SCS) has been clearly stipulated. Even though professional recognition was not ready at the moment, but FTC_02 agreed to catch up in the future.

• FTC_03 answered the first part of the qualifications framework, including garment production was duly established, and worked on the second part which was aimed to be finished within one year. Then the full supply chain would be completed from raw materials to design, product development, production plan, sales down to the garment laundry. Under the qualification framework, workers with years of skills and experience would have a chance to be certified for a relevant qualification. There should be no problem for people graduated from the University and Higher Diploma institution. In the Hong Kong Institute of Textile Association (HKITA), there required a university degree and job experience for membership enrolment in the past, but it has not become more relaxed to recognize a member under its own mechanism. FTU_03 believed the full professional recognition would be in place within a year time.

• FTU_04 agreed there was qualifications framework in textile and clothing trade, but not yet commenced the professional recognition. Actual licensing policy was good for some countries, for instance, higher diploma from VTC together with a few years of experience could attend the licensing examination for qualification which was a beneficiary to the industry. In the textile and clothing sector, although licensing and examination were still not in place, but FTC_04 wished to start and put into practice soon.

• FTU_05 was not quite sure about the professional recognition at presence. But the qualifications framework was there, as such, the recognition should be started with QF levels. FTU_05 believed that it was underway. CITA has already listed out level 3 and level 4 in the SCS which FTU-05 thought was fine. However, general public might not realize that due to inadequate publicity. Anyway, FTC_05 agreed to have the professional recognition in place soon.

In the **question 6**, interviewees were asked about their perspectives on TVET and TVET trainees in HKSAR, and below were their responses.

• FTC-01 replied that TVET was aiming to prepare people to work when they exit. Recently, quite a lot of e-Commerce in the websites could be accessed. In particular, in mainland China institutions, they normally included e-Commerce training such as, 直播, 抖音, 網區, and so on. That was an important and effective thing in which HKSAR was still lagging behind. So, perspective should be stressed in that area. HKSAR was a supportive market and a website like Alibaba was very strong with global customer connection, henceforth, e-Commerce should not just concentrate on one market, rather it should issue a broad profile to allow somebody to contact backwards so as to create more sales approaches. In between, it could also enable customers to realize the strength of the e-Commerce with factories support in behind. Regarding the trainee form TVET, FTC_01 mentioned that, under the prevalence of online paper pattern manipulation or 3D garment design simulation that involved a lot of technical things, actually HKSAR was lagging behind Korea. Therefore, apart from sewing and weaving fabrics, it should be enhanced with more technologies.

- FTU_02 said the market and customers were changing, so TVET should be more sensitive and adaptive to the market with updates and changes as well. Thus, the skills and knowledge could map with the fast changing market. Also, TVET trainees should have wills to develop in the textile and clothing industry, otherwise there was no help after training.
- FTC_03 claimed there should have strategies implemented for trainees. Understood factories would choose graduates from TVET in HKSAR, however, some factories would prefer to pick business or international trade graduates and follow with international training afterwards. Their promotion path might be different since international trading was mainly engaged in sales and orders following up. And product development required high content of technology. There were other types of work such as self-created branding with 3 to 4 partners in a business group. Some business group might be rich with money and vast networks for support, some business group itself might have a garment business or related backgrounds. As nowadays, technicians from factories were not easy to be reached, hence, designers needed to face that issue and be equipped with high content of technology for pursuit.
- FTC_04 reported that in-service training was good for practitioners because it could enhance their knowledge and skill sets as a supplementary which was really a benefit to them. But not much idea on full-time TVET trainees due to being seldom in touch with them.
- FTC_05 said the principal investigator's center was doing very well. During the visit, FTC_05 could see trainees works and new machineries, trainees from secondary 3 onwards could get chance in vocational development apart from traditional grammatical streams, their works displayed were in high standards, and if the trainees got trained from the new machineries, like shoes knitting machine and SANTONI seamless knitting machine, it was definitely do good to the industry and worth keeping onto that in TVET.

In the **question 7**, interviewees were asked about the acceptance of TVET by general public and employers nowadays, and below were their responses.

- FTC_01 replied that it was positively accepted. It was necessary and better to be equipped with training in order to exhibit technical support to industry.
- FTC_02 agreed with the industry, colleagues as well as himself accepted the TVET. Trainees from TVET have a strong ability on skills and competence. For instance, visual merchandising (VM) would be suitable for them, and the company should be able to spot them out from TVET and not necessarily from Universities.
- FTC_03 mentioned factories with the lowest requirement on skills were not in HKSAR, under the generalization of TVET, it was difficult to get in the industry without qualification. In general, degree or higher diploma holders were eligible to get into the industry, but now employers tended to stress on the worker's attitude instead. For example, at the interview stage, employers requested the applicants to stay in their mainland China office or factory for half to one whole day in order to test their adaptability. Employers tended to hire those with strong ability and capacity. Acceptance of TVET depended on types of works, for instance, people from HKSAR

have good potential to deal with US and EU customers due to better language ability during communication. On the other hand, people from mainland China possessed the Russian language ability in Russian market communication along the one belt one road scheme that was better than HKSAR.
- FTC_04 said not quite clear about the public side. However, in full-time study or training, many parents with their rooted mind did not want their dependents to join TVET as they thought TVET institutions were inferior to Universities, they showed bias to degrees, associate and top up degrees that could be articulated to Universities in local or overseas. But there were parents who understood their dependents well and were willing to accept TVET.

Moreover, employers welcomed TVET because they agreed with employees in general lack of skills and craft, and many of them formed their own academy or classes for internal employees training.

- FTC_05 remembered employers in the past preferred to hire people from TVET, VTC, the reason was people exiting from TVET were more solid grounded in design, sewing and FTC_05 thought the acceptance was very high reflected from employers and factories.

Section C– STEM Elements and Activities in TVET Curriculum

In the **question 8**, interviewees were asked how much they knew about STEM, and below were their responses.

- FTC_01 responded that technology, science and mathematics are things. Maybe needed more new elaboration such as, technology things for science, not merely blending of colors, technology was technical skill to sell something, engineering was a bit factual, which was a combination of materials and clothing. Mathematics could be big data or further.

- FTC_02 said STEM topics were strongly existed in primary, secondary and tertiary educational institutes and believed to be good and positive. The aim of STEM education and any fruitful outcome should be the core issue rather than the execution method. Under the changing pace and technological development in the industry, new methods and skills could be adopted and made trainees more to the ground of the society. For example, STEM could be applied in the VM to do some presentation instead of on-site practice. A thousand chain stores could be grouped into one virtual project for display as well as presentation. FTC_02 also believed sample development, cut and sewn development has more direction to develop. Also, STEM could help with paper pattern grading by computer software and system, even the 3D garment design and virtual fitting as well.

- FTC_03 echoed that the background of himself was also from a science stream with experience in engineering matters, therefore, FTC_03 should be familiar with STEM.

• FTC_04 does not have much knowledge in STEM, only the focal words of science, technology, engineering, and mathematics. In fact, each school has different contents to be delivered, the improvement of engines and production facilities should belong to engineering, lean method in production, upgrade of sewing machines could also be counted as engineering.

• FTC_05 replied that she knew STEM had commenced from secondary schools, there were quite many STEM activities for junior form students to participate in voluntary basis. In fact, many people were long for STEM, but there were not many eligible STEM trainers able to teach them. Henceforth, more teachers or trainers have to be outsourced to get together to perform co-teaching. Due to the lack of STEM trainers, it explained the low enthusiasm to push STEM. Anyway, FTC_05 knew what "S" and "T" representing in the word "STEM".

In the **question 9**, interviewees were asked what should be focused on TVET training curriculum and facility and below were their responses.

• FTC_01 mentioned big data was important and all won in STEM. For instance, a seminar could be conducted in a 3D scenario through a computer, buyers needed not to fly overseas to attend a sample show fair, rather they could view through a website with simulation on catwalk show, 3D virtual design and fitting together with data, ERP support as well as other new design system.

• FTC_02 foreseen that smart manufacturing and new retail mode should be the core. Smart manufacturing model could speed up the training, which could be seen in mainland China operating smart manufacture and smart inventory, warehouse control. Regarding the facility, FTC_02 replied that it should be the business of other professionals. By the way, smart manufacturing required a lot of facilities to support.

• FTC_03 reiterated that the training facilities should be consistent with the machineries and facilities currently used in the factories, since they could pick up the operation easily when they worked in the factories. Also, trainees have to be equipped with trendy, prevalent technological knowledge background, for example, body scanner, 3D CAD software, computer cutting bench, CAM system and so on for personalized products. As such, TVET needed to incorporate those expensive facilities for the goodwill of training. Regarding the training curriculum, the training facilities used must be the same as in the industry, trainees have to know how to operate trendy machines. Therefore, the curriculum was better to embrace work integrated learning element (WIL) or work integrated education (WIE). Similar to Taiwan, HK PolyU requested 120 hours in WIE, CBA in Engineering in France. Within 5 years of study, students have to spend 1 whole year in the industry for attachment. There was a "sandwich" course offered in HKSAR in the past for working adults, they had to study for 1 day with 4 days released back to industry, which was quite similar to the earn and learn scheme in VTC. All those who could support STEM to develop as real practice and experience was more essential than merely learning the theory.

• FTC_04 said the four elements in STEM were all vital for the contemporary society. Especially, technical issues were important for different streams and curricula that should be tailor made for different students. And those four elements needed facilities to support, like laboratory to support science and data color system to support color systems.

• FTC_05 mentioned that if technology was built into the course, then related facilities had to be cope with that. CAD should be adopted in paper pattern design process with a powerful computer, design drawing should be accompanied with the 3D CAD software, just like secondary schools were using 3D printers, so on and so forth.

In the **question 10**, interviewees were asked about their opinion on exploration and incorporation of STEM activities in TVET curriculum or courses, and below were their responses.

• FTC_01 agreed to enhance and incorporate STEM activities in TVET so as to increase the incentive as well as the involvement of the trainees. For example, by using 3D software, it was more quickly to view the garment draping effect when compared to the traditional cutting and sewing processes that took a long time for visualization.

In short, it took almost a month from design to the final garment in the past, which saved a lot of time now with the aid of technology.

- FTC_02 agreed to explore and incorporate STEM activities in TVET curriculum or courses.
- FTC_03 also agreed to explore and incorporate STEM activities in TVET curriculum or courses.
- FTC_04 absolutely agreed to explore and incorporate STEM activities in TVET curriculum or courses, in particular, in-service training needed that very much.
- FTC_05 agreed to explore and incorporate STEM activities in TVET curriculum or courses which seemed to be a must.

In the **question 11**, interviewees were asked how to implement STEM activities in TVET curriculum or courses in HKSAR and the resources required, and below were their responses.

- FTC_01 responded that qualified teachers needed to be carefully considered or changed whenever necessary, teachers were required to possess experience on virtual technologies by further learning or staff development and training. It should be better taught by people from industry. For example, e-Commerce to be taught in mainland China, since the right people were there, henceforth, all round marketing could be done in a team and really workable in the real industry. Industry support and money were the main resources required.
- FTC_02 claimed the first part was to enhance the basic knowledge and skills during school lessons, the second part was to speed up the merging with industry and corporates in collaboration on work-integrated learning. The collaboration between schools and corporates

has to be strongly matched and recommended starting early before the course completion to let trainees know the advantages of authentic workplace learning. Anyway, the training role should be borne by school or training institutes because corporates' role was to focus on business and profit-making areas.

Resources could be requested from Government of HKSAR, especially in the youth development scheme, funding from the Government in assisting TVET could possibly allow a win-win situation in corporates. Apart from the production, the corporates could also train up the right successors to sustain the industry thereafter. The content of the curriculum and course should fit the needs of corporates, then the corporates would be willing to invest for future needs. Of course, the Government of HKSAR would need to replenish the loss from production as a result of industry training and attachment.

- FTC_03 reported there were two aspects. One was the economy, and the other was the supply of courses which have instructors to deliver. However, the demand for courses from industry was a bit complicated, especially under the trade war between mainland China and US that affected the willingness of corporates to invest in staff training and development. In the coming trend, large enterprises would become large and SMEs would diminish. And large enterprises could afford to set up their own training academy, therefore, it seemed a chance for TVET to pair up with SMEs who could not afford their own academy for training. Regarding the resources, it concerned mainly on funding and facilities, employees were not likely to spend their own pocket money in TVET courses.

- FTC_04 mentioned that Arkin from industry always quoted 人(instructor who know how to teach), 機(machineries and facilities), 物(enough material for practice), 法(methodology in delivery). The final resource was funding support from the Government of HKSAR. For implementation, it needed to have good promotion to change the mindset of the public on contemporary technologies that were totally different from the past. Parents' mindset also needed to be educated and changed. Together with the social education in primary and secondary schools on abreast concept of technologies nowadays.

• FTC_05 said the Government of HKSAR needed to support, and funding to purchase facilities was required for hardware, software. Last but not least, the training on instructors and staff development needed to be in order.

In the **question 12**, interviewees were asked about the STEM knowledge level of TVET trainers in HKSAR, and below were their responses.

• FTC_01 replied that the STEM knowledge level of TVET trainer was just so so which should not be enough for future needs. In particular, 3D software and big data were essential for the industry.

• FTC_02 reported that they did not understood the background of the trainers. In Huizhou institute of mainland China, it paid more importance to TVET, they requested new trainers have at least 3 months of industrial attachment in an enterprise to understand the intact operation before teaching. No such calling of "STEM" in mainland China. Trainers there could acquire more new and down to earth knowledge to teach who might be very professional in a subject. By the way, enterprises in mainland China also has resource to send out their trainers for staff development.

• FTC_03 reiterated that HK PolyU also got STEM elements in teaching, and depended on trainers' on-the-job experience. In HKSAR, there should have enough trainers with STEM knowledge and skills to teach. Since it involved too much new and emerging knowledges, we have to rely on a supplier to play the role of teaching instead.

• FTC_04 has no idea about that, and it reflected that might vary from higher diploma level to degree level.

• FTC_05 thought their knowledge were not enough. As STEM was very new, and nobody could specialize in STEM teaching. It might therefore be needed to outsource those organizations which specialized in STEM education. They have STEM courses but not many in the fashion and textile area, at least to find someone like Benny who recognized STEM which could infuse that into the course. Staff development by sending trainers for industry training and back to update their own course content.

In the **question 13**, interviewees were asked about how effective the STEM activities in TVET benefited the sustainable industry, and below showed their responses.

• FTC_01 agreed it was effective and positive. Also, it engaged many people's devotion that should help the industry.

• FTC_02 mentioned there was an Eco yarn mill in HKSAR with many investments. That was a good concept on the part of less labor hired with many machineries located inside the mill to increase the gross output. He believed many STEM elements were practiced in primary, secondary as well as tertiary educational institutes which was effective and valuable. That was also welcomed by parents and students and no negative voice heard from the society so far.

• FTC_03 said that if the staff has undergone STEM training and acquired a deep knowledge in foundation technology, the staff could pick up new technologies much faster in a shorter period. Sustainable industry actually depended on how many new emerging technologies replaced the old ones. In principle, FTC_03 believed that STEM activities in TVET could benefit the sustainable industry.

• FTC_04 thought that was good and effective. Trainers could upgrade them with the ability to deliver related and update skill sets to trainees that helped the industry. Of course, to teach update technologies required updating facilities. For instance, the SHIMA, STOLL and SANTONI seamless knitting machines were good for in-service training too.

• FTC_05 replied that it could enlighten students in secondary and tertiary education. Apart from the research business, other industries also needed to know about STEM for communication. For instance, sales department in garment business made use of big data for analysis, and therefore it could be helpful in marketing and publicity. FTC_05 also agreed that it was effective to add STEM activities in TVET in order to help the industry. Examples cited by her were wearable technologies, 3D scanner technology of body measurements in wedding gown design and customization in production.

Section D– Relationship between TVET and Sustainable Industry

In the **question 14**, interviewees were asked about the challenges that the FTC industry is facing in order to achieve environmental sustainability, and below were their responses.

- FTC_01 responded that science could help a lot indeed. For example, using 3D simulation to weave a fabric, saving time to do the actual sample, no emission, no transportation and logistics were required for the presentation to customers that matched the environmental sustainability.
- FTC_02 mentioned that many people were concerning environmental sustainability. Eco technology like waterless denim washing was believed to be workable and mature soon. Initial cost might be high, but would lower down upon commercialization. It was also good in energy saving, carbon dioxide footprints tracing as well as discharge control in the industry would definitely improve the living.
- FTC_03 claimed there was no problem in HKSAR since no factory exist now. Even though no factory exist, people should also choose eco-friendly materials or methods for the process. STEM knowledge and background are supposed to be good to choose, to justify with the reality.
- FTC_04 pointed out the challenge on cost. Although eco-things normally were at high cost, but had to go and react if sustainability was raised. In the past, eco-technology on water treatment was the utmost expensive. Upon the technology became more matured, the relevant cost was gradually coming down. Besides water, air and solid waste, landfill was also vital in

the recycle process which is still standing with high cost due to immature technology at presence. So technology was still needed to be advanced in order to lower down the recycling cost.

- FTC_05 reported there were many challenges, textile industry consumed a lot of water, production of denim contaminated the environment a lot. Upon technology advanced, printing and dyeing consumed less or even no water along the production process. Fast fashion actually wasted a lot of resources. Nowadays trend, people were talking about customization to remind them to purchase less and discard less and avoid adding burden to the earth.

In the **question 15**, interviewees were asked about whether TVET bears a high value in providing feeders to a sustainable FTC industry, and below were their responses.

- FTC_01 agreed to that in the reply.
- FTC_02 agreed to that and reiterated the provision of human resource needed to meet the fast changing market. For instance, smart manufacture for denim products.
- FTC_03 agreed and the industry wished to find quality people for jobs, but the people in the industry possessed low skills content that might not be able to spot out and tackle the problem efficiently. The key thing was to prevent a problem rather than solving a problem. As such, STEM knowledge was important for accomplishment. For instance, to spot out problems during the sample stage could prevent them from happening in the bulk production.
- FTC_04 agreed and said it was very good. And mentioned her recent trip to ITMA 2019 in Barcelona, Spain. A company called Jeanologia was focusing on Eco development, like treatment of waste water, and it always required human resource. This company was willing to carry trainees and provided training on a free of charge basis. They recruited more and more trainees from Shanghai for half a year on-site training in their factory. For graduates from TVET in HKSAR, it was good to have external industrial attachment with authentic

workplace training so as to get added value and merit. Therefore work-integrated learning was the utmost important.

• FTC_05 agreed and said the industry relied on TVET to provide manpower to them to sustain.

In the **question 16**, interviewees were asked about the elements in TVET for a sustainable industry, and below were their responses.

• FTC_01 claimed that the mode of survival in the industry has been changed, and those changes were required to be matched with the ways of 衣, 食, 住, 行. In website Alibaba, garment has occupied a greater portion, depending on the matching model, big data has to be run fast in time.

• FTC_02 viewed from another perspective, there was no contradiction between industry survival and environmental protection, and hoped TVET should bear environmental sustainability in mind to train the trainees that also needed to include ethic and compliance. For example, during the color dyeing and management process, trainees should also know how to handle dye stuffs and its impact on the environment.

• FTC_03 said trainees needed to fully know what was sustainability, not just environmental but also cultural sustainability which required a designer to consider or even about an ethical problem, such as rich and poor, child labor, production in prison were also part of the sustainability issues. As one could see, the orders from customers were encompassing ethical, environmental as well as cultural compliances inside.

• FTC_04 reported that STEM was a must. Because trainees attended industrial attachment or on job training upon completing their studies, they could meet sustainable issues. In fact, the changing of mind set on TVET was also a sustainable element, not necessarily for everyone to go to the University!

• FTC_05 mentioned that an Eco-concept was required in printing and dyeing. To use up the left over fabrics after cutting in the design stage, how to use paper pattern markers to optimize the use of fabric, and the concept of recycling, so on and so forth. An example cited was a collaborative project between HKRITA and H&M and the Mills. A recycling process from old and used garment to re-designed, re-made new garment could happen within 40 feet container at around 7 hours. And it was understood that the magic process could speed up in 4 hours. The reason for using a removable 40-foot container was to enable that could be practiced at anywhere in any district. Henceforth, one could get back a new garment after lunch even though the cost was still high at the moment!

In the **question 17**, interviewees were asked about the linkage amongst STEM, TVET and SD in the industry, and below were their responses.

- FTC_01 responded that 3D printing technology could print out the product directly, no more need to cut down trees and weave cotton fabric. Science assisted to protect the environment and minimize the transaction time, which was already protecting the environment. STEM could be adopted to achieve that goal, like 3D simulation of fabric to save up lead time with less real fabric weaving and production.

- FTC_02 replied that three aspects have a connection and linked together on a foundation level indeed. TVET was aimed to generate graduates with basic and foundation skills to fill up the posts demanded from the industry. STEM acted as a tool in teaching methodology to arouse trainees' creativity. And everything should be sustainable, SD was a must in our daily life.

- FTC_03 described STEM as

a kind of knowledge base, TVET enhanced practice to acquire adequate experience, and STEM together with TVET made SD work and bloom as a whole.

- FTC_04 reiterated that TVET should include STEM as well as SD in order to be practical and useful to the industry.

• FTC_05 said those three aspects must be linked up, it has to be worked out by the specialists from STEM, TVET and SD.

Section E– Attitudes, Skills, and Competence of trainees/ graduates from TVET Organization

In the **question 18**, interviewees were asked about the comment on the learning attitude of trainees in TVET embedded with STEM activities, and below were their responses.

• FTC_01 said their learning attitude was good, more vivid, and more satisfaction and achievement. It could also arouse trainees' interest with less frustration and, as a result, save the time and expenses in training.

• FTC_02 agreed it would do good to trainees' interest, especially, part-time trainees could learn new methods on new thoughts. And the entire industry felt more vivid rather than a deadlock.

• FTC_03 said students should accept more dynamic teaching, then it leads to a better retention. As STEM activities were kinds of dynamic approach to train students for appreciation, practice and participation together with wordings to conclude and round up, which would be an effective mode of learning. Students reflected more concentration instead of merely reading books in a learning activity.

• FTC_04 reported in-service practitioners demonstrated positive attitudes in learning with STEM activities since they have to learn and compliment their inadequacy in order to deal with customers. But not quite sure about the situation in full time students, FTC_04 believed the learning attitudes of in-service practitioners were better than those of full-time students. Perhaps the mind sets of full-time students have to be changed so as to exhibit good and positive learning attitudes. VTC should launch more in-service training course, hire expert part-time trainers from the industry who possessed good experience and technical skills.

• FTC_05 responded that it would be welcomed by students, STEM in activities could enlighten students in learning instead of solely theory study. It would be much better if they had already got in touch with STEM during secondary school.

In the **question 19**, interviewees were asked about their views on skills and competence of TVET trainees in mapping with the FTC industry, and below were their responses.

• FTC_01 thought their skills were just so so as there was a science and technological gap existed among generations to meet the demand from the market. It needed more revitalized and proactive jobs, sales models to replace those old and boring works,

• FTC_02 replied that there were 70 to 80 percent of them that could map with the industry. As some of them were still lacking practical experience in the workplace because there were quite a lot of new facilities and machineries turned out, trainees had to learn and adapt things which were different from the school during training. It was hardly possible to determine what those new machineries were, and trainees could not possible to learn all the machineries. Henceforth, trainees have to enter the corporate to learn and adapt for compliment. And the Government of HKSAR should provide more support for those work-integrated learning arrangement.

• FTC_03 said their skills and competence were basically mapped to the industry that could be seem in the qualification framework.

• FTC_04 recalled from her past views that VTC students were more practical than HK PolyU students. Their expectations were not so high that might lead to losing of confidence and self-depreciated, but seemed good because they were willing to take up lower rank and hands-on jobs. In the past, there was no advocacy on STEM and was supported with advance machineries. However, under the bloom of STEM recently, their skills could somehow fill up the gaps and map in the industry. As there were various kinds and levels of jobs, people have to keep themselves up in the lifelong learning path so as to remain updated and abreast. A non-stop knowledge acquisition pathway from technical knowledge to production and, finally to management knowledge aspects.

• FTC_05 replied that skills could map to industry in principle, but the mind set might not be the case. For example, there might be a false expectation from trainees to work on fancy and vanity design collection once exit from TVET which was not the fact indeed. So, TVET should let trainees know the actual scenarios and operation that matched typically in the industry to avoid misunderstanding and expectation gap thereafter.

In the **question 20**, interviewees were asked about the employability and mobility of practitioners from TVET, and below were their responses.

• FTC_01 reported there were more chances in the greater bay area rather than HKSAR. Since most of the companies were located in mainland China, and many successful companies were being well trained in e-Commerce model by Alibaba in mainland China, which was highly acceptable. FTC_01 wrapped up that employability and mobility in HKSAR were just so so due to the diminishing investment from factories in HKSAR.

• FTC_02 claimed there must have been employment in HKSAR, but might not be fully employed. Employers care about the contribution from employees to their corporates, graduates from higher diploma courses might not be worse than degree holders regarding the output. In the design sector, a saleable product would determine the success no matter what qualification was behind it. FTC_02 admitted the mobility was fine and result oriented in the corporate.

• FTC_03 mentioned vertical mobility although skill sets helped in the actual workplace, but promotion required enough experience together with managing ability. As such, head hunting activities occurred among enterprises, therefore, employability and mobility were always there subject to skill sets and aggressiveness of the employees. Another reference on mobility was the willingness of employees to work abroad. Some chambers in HKSAR were encouraging minorities to travel and go back to their own countries and acted as a bridge to communicate across their countries and HKSAR. That was quite different in the past in HKSAR, people still have the privilege of bridging across factories in Mainland China due to the proficiency in Mandarin. However, that was not the case in offshore countries, which explained why minorities were encouraged because of their appropriate language proficiency in offshore countries, like Bangladesh.

• FTC_04 thought that both employability and mobility were fine. The upward mobility depended on pretty much on employees' actual performance and related further study. Anyway, it could help the lower working class.

• FTC_05 reported that the industries in HKSAR were down-sizing, and many factories have been relocated to Mainland China and offshores. Hence a poor record in relevant employment was noted. However, jobs in retailing, design and merchandising were still in demand under a changing mode of operation, therefore, employees have to learn and adapt in order to keep mobility. Especially, they were required to further upskilling or learn to ride on the upward mobility. For instance, a designer might need to further study in business management and business operation for promotion in all industries.

In the **question 21**, interviewees were asked whether or not employers satisfied with the performance of the current practitioners (level of skills and depth) from the industry, and below showed their responses.

• FTC_01 claimed their skill sets and training received were not comprehensive enough, so the satisfaction from employers was just so so. The training conducted in schools was more factual, which should require more vibrant and flexible application at the workplace. In fact, students have to learn how to learn due to the ever-changing market and environment.

• FTC_02 replied that employers would not expect too high, they would treat them as a blank paper and more easy to shape for companies culture and operation. Overall, FTC_02 satisfied with their fundamental skill sets upon graduating.

• FTC_03 reflected satisfaction on them as corporates in HKSAR were still hiring people from here.

• FTC_04 said the satisfaction depended on people and their working attitudes, dedication to job, academic as well as their actual abilities in the workplace.

• FTC_05 reflected their skill sets were basically enough and satisfactory. More concerns have been put in their mind sets about whether they could cope with the development in the corporate or not. Example cited was designers quite often turned over in the corporate due to their designs not mapping with the customers demand as well as corporate direction. A communication gap was seen between design and merchandising department in which customers information and demands could not be clearly and smoothly passed from merchandisers to designers within a corporate.

Section F– Views on Future development and advancement in TVET

In the **question 22**, interviewees were asked about any new idea for TVET to develop and advance, and below were their responses.

• FTC_01 mentioned about the technology, in particular, computer software was important for body measurements.

• FTC_02 responded that more attention should be paid to mainland China and S.E. Asian countries that have more needs and potential in development. The foundation skills of youngsters was still fine in HKSAR now, however, after five to ten years later, they might encounter more difficulties and challenges from outside since HKSAR was small and gradually losing its competitiveness in design and retail sectors. Therefore, new ideas should be focused on the retailing end and then working backward from the customer market to the origin of sourcing as well as design.

• FTC_03 said the direction on development should be put in familiarization with automation, as the ability to demonstrate through a robot and artificial intelligence was becoming more important. TVET has to stress on those new areas and application in the workplace. People might also need to consider and swap to other emerging business. So the technicians have to upgrade their skills from machine operation to computer operation. Since the shift of skills and operation were essential, large and personal enterprises would tend to engage in small quantity with high added value production in order to sustain. For example, invaluable handcraft skills should be kept and sustain.

- FTC_04 said the industrial attachment in the workplace was important, which was named work integrated learning (WIL) that was similar to the sandwich course in the past years. Students swapped between study and industrial attachment modes in half a year time for learning and practice in the workplace. That could also be found on TVET in the UK and Germany. FTC_04 said that it could be re-packed for a new face.
- FTC_05 reiterated that communication between TVET and the industry was the utmost essential, the content in TVET must be mapping to the industry.

In the **question 23**, interviewees were asked about any negative impact from TVET received from the industry so far, and below were their responses.

- FTC_01 responded that there was no negative impact heard from industry and only depended on how to learn and apply.
- FTC_02 also said no negative impact received from the industry. However, the corporates in HKSAR might shift away their operation from hiring workers in HKSAR owing to the problems of high wages and costs. Consequently, trainees from TVET might not be able to find jobs in the market. And corporates could always make a decision on recruiting trainees from other places other than HKSAR under the costing concern. FTC_02 reiterated science, technology and research must need to link up scholars in mainland China and carefully consider which type of jobs required professional training, how large that market

share was, as well as the competitiveness as a whole.

• FTC_03 mentioned the income adjustment of workers was not in pace with the market, especially, the slow increment in the production sector has been observed.

• FTC_04 did not think there was any negative impact, only parents was demonstrated less support in TVET. As such, it was crucial to have their mind sets changed.

• FTC_05 reported no negative impact heard from industry so far.

In the **question 24**, interviewees were asked about whether STEM activities would be able to enhance trainees from TVET's knowledge and skill competence basis to meet the challenging sustainable industry in the 21st Century, and below were their responses.

• FTC_01 replied that it was positive. Trainees from TVET should receive actual practical training, participation and realistic application in order to meet the sustainable industry.

• FTC_02 basically agreed, and that was also accepted in the general market, and things would gradually come out.

• FTC_03 also agreed.

• FTC_04 agreed and was sure about that subject to the provision of an adequate update and down to earth STEM resources

• FTC_05 strictly agreed.

In the **question 25**, interviewees were asked about any important information missed out from the survey, and below were their responses.

• FTC_01 has no more return.

• FTC_02 wished TVET besides to focus on the local market which was less competitive and shrinking. It should also need to prepare the trainees to reach out to other markets which were more diversified and had more potential in development. As a whole, due to the limited prospect seen in HKSAR, TVET should consider the demands from other countries.

• FTC_03 said the Government in HKSAR should support and take role in the STEM in

TVET to meet the challenging sustainable industry in the 21st Century.

• FTC_04 reported that there was no more supplement and wished STEM success.

• FTC_05 has no more return.

Session 2. Focus group of trainers in TVET for FTC industry

Section A – Implementation of STEM-based activity in TVET

In the **question 1**, interviewees were asked about their overviews for the implementation of STEM activities in TVET courses, and below were their responses.

• TRR_01 mentioned there was no separate STEM section in lifelong learning and teaching areas, however, STEM was infused into the courses concerning textiles.

Indeed, there were several methods for implementation, quite a lot of practical workshops involving machineries, trainees must be theory support in order to operate the machineries. Within the theory, some mathematic elements must be involved, engineering involved machines operation, especially, fabric structure and construction was already counting in engineering. Moreover, textile printing and dyeing were all related to chemical science. Solely learning the theory without a practical workshop was impossible, as most of students were bearing the secondary school mathematics that was different from textile mathematics. Under the negligible knowledge, they have to learn practical works as well as machine operation in order to enhance their understanding. For instance, students have to carry out experiment, by using a microscope, burning test or chemical test under the STEM activities to differentiate various types of textile fibers and their natures.

• TRR_02 said that CITA has organized STEM courses and cooperated with secondary schools, it seemed quite new and creative to combine STEM with 3D CAD software with the aim to infuse STEM into the 3D software.

• TRR_03 reflected that STEM activities were good for students, but mathematics might be bored.

• TRR_04 thought that it would be a greater depth as trainees received actual practice rather than merely theory instruction. During the practical, it was good for trainees to dig out the problems, looking for a feasible solution so as to enhance their understanding in learning experience.

In the **question 2**, interviewees were asked how to implement the STEM activities, and below were their responses.

• TRR_01 responded that implementation must be worked hand-in-hand with industry. As the speed of new things development was much faster observed in industry than TVET, therefore, TVET and students should go out and learn from industry. They could learn through social media and YouTube together. So, implementation should be in multi-facets, an example cited was a big VR project collaborated with the industry for interactive and interesting learning in textile processing. The interdisciplinary participation was vital, textile instructors have to work with engineering department as well as programmer together with the input from industry to prepare appropriate and update learning and teaching packages in the VR program. Since the VR experience was essential to encourage and enhance trainees in understanding of spinning, dyeing, weaving, finishing on yarns, fabrics and accessories. For example, trainees seldom got a chance to visit cotton fields or organic farms in north west China such as 新疆. Henceforth, various parties played different roles in the implementation of STEM activities for learning. To elaborate, textile instructors provided relevant knowledge and context, IT engineers responsible for program writing, industry helped to arrange a site visit for video and photos recording.

And the whole process could be explained to in-house trainees in an animated presentation without the limitation on time, venue as well as safety issues concerned.

• TRR_02 said that students studied visual arts and science also bore relationship with 3D software and mathematics. Furthermore, engineers engaged in the operation of computer and software and prepared them for designers to use since fashion design, especially the paper pattern engineering, must require mathematics and computer software for backup, therefore, all those mentioned were fit into STEM. In the past, trainees were taught through traditional hands-on methods to do paper pattern drawing, cutting of fabric, garment sewing with the aim to try out the fit on the mannequin, but nowadays, all the above procedures could be done within a 3D CAD software. Color hues and tones could be set inside the 3D software for application of graphics and virtual design on the computer. In addition, virtual paper pattern manipulation as well as virtual sewing on a garment was eventually simulated in the final look on the avatar and viewed from the monitor of the computer, which was absolutely convenient and useful for immediate group discussion and sharing during the course.

- TRR_03 agreed that two thirds of a 3-hour-long training course needed to include STEM activities in order to achieve flexibility. But the trainees were requested to provide feedback or conclusion on what has been learnt and whether the expected outcome could be met or not. For instance, trainees were taught through the printing process, their difficulties and problems encountered could be recorded and shared for more discussion and clear understanding. That would hardly be achieved by merely watching the videos.

- TRR_04 replied that a company and factory visit could be arranged for trainees, demonstrated the hands-on works and coached trainees in the workshop practice that all enable them to experience and understand more the authentic operation in the workplace. So it was helpful to implement those kind of activities indeed.

<u>Section B – Difficulties and Constraints in practical workshops</u>

In the **question 3**, interviewees were asked about the difficulties and/ or constraints encountered during implementation, and below were their responses.

- TRR_01 reported during the VR project, so many supports like, manpower from different sectors and extra manning, funding and time were needed to be considered. They had to consider the support from top management, how to coordinate with interdisciplinary colleagues, any mutual benefit or win-win situation, and so on were required to be figured out clearly during the implementation.

- TRR_02 replied that as all the virtual processes were set inside the computer, if computer software failed to work, then all works would be ceased, and that was the limitation that came across. Also, trainees could not smell the materials as well as touch the fabric that lack of tactile feeling on real textiles.
- TRR_03 said difficulties and constraints were mainly due to the inadequate facility to fulfill all the trainees. When new information and technologies were brought in the curriculum from industry, trainees might not be able to accept them easily. To drive those in success, efforts from the various department and parties were absolutely required.
- TRR_04 claimed the main problem happened in school workshops. One instructor might not be able to look after a large group of trainees, so it was better to have an assistant to help, especially when there were problems raised by the trainees. Sometimes, it was necessary to have two to three assistants help with solving the problems during the delivery if the class size was around forty to fifty, otherwise, it would be ended up in a time wasting manner.

In the **question 4**, interviewees were asked how to overcome those difficulties and constraints, and below were their responses.

- TRR_01 reiterated great support has to be received from top management, DED C across various disciplines. Also, industry had to provide strong support and working parties were required to possess professional knowledge to work on.
- TRR_02 replied that the 3D scenario viewed from the computer was very realistic even though trainees could not experience the tactile feeling on real materials. In fact, the 3D software got a functional icon to apply a handy pull (by using the mouse) on the virtual fabric

to observe the drape of the fabric through the monitor, hence, the 3D software could overcome that!

- TRR_03 said most of the instructors from industry were very good, they brought trainees to visit fashion fairs, factories, companies and events launched by industry so as to widen their vision in the contemporary industry. For example, trainees could see and understand how the new laser printing technology works before graduation. They could also learn and apply during the internship for authentic practice as well. For in-service trainees, they were coming from different backgrounds in design and merchandising, showing more interaction, sharing new ideas among themselves as well as searching for new technologies proactively.
- TRR_04 replied that to overcome difficulties and constraints was to hire workshop assistants or divide the large class size into sub groups during delivery for better caring for trainees. For instance, one group was taught as normal in class, whilst another group would be arranged in e-learning mode after breaking up. Although e-learning was a common practice, however, it was not an ideal solution in learning due to the lack of real practice and interaction among instructor and trainees. The instructor was not able to realize the response or problem from the trainees and would not be able to solve the problem on-site immediately. Moreover, e-learning was not difficult indeed because most of the information could be located through website browsing, but it was helpless in answering a question or problem as no interaction could be done during the learning process.

<u>Section C – Resources and facilities required</u>

In the **question 5**, interviewees were asked about the resources and facilities required for full implementation, and below were their responses.

- TRR_01 responded that many machineries were required, especially in the textile technology area. Also, there required a lot funding, manpower, computer facilities in the VR project. All those machineries and facilities were distributed across various disciplines, therefore, it was good to collaborate and share upon the full implementation to solve the limitation on location.

• TRR_02 reported the 3D software, funding and sponsorship were the required resources. For the facility, it was vital to have a computer room equipped with computer facilities. In CITA, some more props, paper pattern tools and sewing machines were required to explain to trainees about the normal practice in a garment factory for knowledge on traditional ways of garment manufacture.

• TRR_03 mentioned more interaction with industry and purchasing more new machines were required for full implementation. Actually, trainees could go back and practice on those machines after graduation in order to keep the optimal utilization. For example, HK PolyU has that kind of practice, graduates could go back to book their photography studio free of charge for projects which could maintain an update on technology. They could also use artificial intelligence, photoshop, paper pattern software, tie dye and silk screen equipment in the laboratory that kept up the utilization. Training schools should launch such the related short courses periodically for practitioners with an attractive fee for lifelong study and advancement. Nowadays, since there were many small brands and individual designers, it was hardly to incorporate too many machineries like laser printer, digital inkjet textile printer and 3D printer. As such, TVET could consider supporting them with the aim to improve the employment rate. Of course, funding support was also an essential issue to be included.

• TRR_04 said the workshop with realistic machineries and hard wares was important in implementation. Otherwise, it was difficult to enhance trainees learning and understanding just by using photographs. Since trainees could feel and experience the actual difficulty and problem during in touch with authentic facilities. For example, solid teaching materials were vital in conducting STEM activities for practitioners from industry during the training course.

In the **question 6**, interviewees were asked how to incorporate those resources and facilities as well as the cost concerned, and below were their responses.

• TRR_01 replied to seek funding and advice from industry on updating information for purchase, preparing enough room and space to house those facilities. All those new and advanced machineries together with the professionals might incur a very high cost eventually, even though it was hard to estimate under a broad circumstance.

• TRR_02 has no idea on the costing, rather, room, space, computers and related tools were the required facilities.

• TRR_03 mentioned that it was hardly possible to breakdown the overall costing. For instance, a small company usually could not afford to purchase a large plotter for paper pattern printing owing to the concern on cost as well as limitation on space to house that machine. However, training schools and centers perhaps could do so, they might need to do more publicity to encourage practitioners from the industry making use of Saturday to come back to practice on the machineries.

• TRR_04 replied that there was a need to install facilities for long term purpose as well as sustainable needs, especially for those expensive facilities that could enable trainees to use them frequently thereafter.

Section D – Trainees' learning attitude & receptivity in STEM-based activity

In the **question 7**, interviewees were asked about the learning attitude and receptivity of trainees during the workshop embedded with the STEM activities, and below were their responses.

• TRR_01 reported the experience in the VR project. Trainees demonstrated their interest in all new experience as well as good and positive learning attitude on new and interesting things. TRR_01 also believed that trainees accepted the workshop embedded with STEM activities as they were fond of hands-on practical exercises and authentic experience during participation which embraced factory visit, laboratory experiment and VR experience that could allow them to create more noise and impact in order to enhance their learning and understanding.

• TRR_02 replied that trainees showed high interest, receptivity and good attitude to try, learn and enjoy, they were very creative and disregarding failure.

• TRR_03 believed trainees would accept that and be able to tell back and share what they have learnt in the workshop as well as less boring when practicing hands-on activities. Instructors could also praise those trainees who have done good works during the workshop, therefore, trainees would feel happy and encouraging upon receiving feedback from their instructor that is really motivation for their attention and retention during workshop time. For instance, experimental works fibers and yarns by using a microscope to differentiate natures and structures was an important STEM process for verification. That could also create a good atmosphere to cultivate learning outcomes.

• TRR_04 said trainees would be happy and accept that since they could get actual experience and benefit a lot during the learning process, in particular, for those practitioners from the industry. They thought hands-on practical workshops were more useful to help with understanding. So TRR_04 thought that was positive and acceptable by trainees.

Section E – Overall outcomes and effectiveness in performance

In the **question 8**, interviewees were asked about the overall participation of trainees in the workshop, and below were their responses.

• TRR_01 reflected that trainees usually demonstrated good participation as they were requested to report what has been learnt and experience during the workshop.

• TRR_02 thought trainees' participation was almost 100 percent due to the interesting, freshly and exciting activities conducted in the workshop.

• TRR_03 replied that if there existed two third of practical timeslot in the workshop, then the trainees would show initiative participation, also a positive mutual influence among trainees that led to constructive competition thereon.

- TRR_04 responded that their participation was quite good under a close assistance situation. As trainees were rarely in touch with machineries which made them feel new, so if the instructors and technicians could explain and answer their queries next to them, then it would be more effective with good participation observed.

In the **question 9**, interviewees were asked what the learning outcomes including knowledge, skills, and/ or attitude in STEM were observed, and below were their responses.

- TRR_01 claimed trainees should do the self-evaluation, it was better to have industry involvement after the completion of the workshop or project. They knew the application of knowledge in a real situation. For example, the designers from the industry could provide comment and feedback to trainees' works regarding denim design, trend book recording the technology on printing and dyeing of denim fabric during their presentation on the final application on denim products to enrich trainees' knowledge in order to meet the industry demand. Therefore, it could attain a good outcome.
- TRR_02 believed it was fine and observed the trainees could really learn and apply the skills in the mini group project.
- TRR_03 mentioned their attitudes became more constructive and observed they really enjoy the learning experience. Under the pleasant learning experience, trainees' knowledge and memory on operation became more deepened. Henceforth, STEM activities were absolutely vital and necessary for upskilling after an authentic practice in workshop.
- TRR_04 observed that there was an increment and improvement on the relevant outcome, including knowledge and skills in STEM.

In the **question 10**, interviewees were asked about the effectiveness of STEM activities embedded in the TVET course for the FTC industry, and below were their responses.

• TRR_01 agreed it was effective and innovation was being highlighted in industry. She hoped trainees could acquire up-to-date knowledge during practical training, testing as well as hands-on crafts to match the expectation from the industry. Therefore, TVET was still needed to cooperate with the industry.

• TRR_02 responded that STEM activities looked fine to short courses lasted for one to two days. In view of long-term running, theory part needed to be infused. As such, a more all-rounded training course should consist of both theory and STEM activities. For trainees from industry, more theory part could be considered whilst students from secondary schools, more focus on STEM activities that might arouse more interest on them as they did not have too much knowledge about the industry.

• TRR_03 believed that it was good and effective which could strengthen up the confidence and ability of trainees to absorb new things from the industry. Since they knew the world was updating, so they have a strong desire to learn new things. From TRR_03 experiences in the past ten year, trainees would share and feedback their learning experience during the factory visit, fashion fair visit and so on. Especially in in-service training, a mixture of trainees including foreigners who influenced each of the other during the peer group learning is common. Also, trainees were encouraged to view the YouTube video before any discussion in the lesson. To cite a successful example, trainees could learn the sewing procedures and operation on sewing machines through YouTube and then go back to the real practice in a sewing workshop that helped a lot indeed. When this model of practice applied to another machine, trainees could jump into the workshop effectively at a very fast pace. Since trainees were afraid of boring, they would rather like to listen to the jiggling sound of machines instead of the boring tones from instructors!

• TRR_04 believed that good and no harm was to be done. As only theory teaching, trainees could not see and experience the real machineries, and did not realize the difficulty instead of purely imagination that was not practical and ideal. He agreed real practice could do good to industry.

Section F – Views on future development and advancement in STEM-based activity

In the **question 11**, interviewees were asked about any new idea for a STEM-based activity to develop, and below were their responses.

- TRR_01 responded to multi-disciplinary ways of collaboration like the aforementioned VR project was important. It involved IT and engineering students working together and co-brained on the design and processing of the co-learning process. Actually, some mobile games could teach about fashion and textile. For instance, an AR program on goat trapping in which students could learn about different species of goats and then their characteristics of wool types that brought more interests and vividness during learning.
- TRR_02 mentioned they have organized a virtual fashion design competition inviting secondary school students to participate. It just took a several lessons to teach them the elementary knowledge to operate before designing a virtual garment by using the 3D CAD software which being put onto the avatar of a virtual catwalk show. By adopting the vote on a line basis, the winner would come out at the end of the process quickly. In fact, the virtual design could be realized into a real product like adding a design pattern on a Tee shirt, and then printing out the paper pattern and eventually sewing up a real Tee shirt for fitting.
- TRR_03 aforesaid that instructors and trainees have to be well-prepared before coming to the lesson, like viewing the sewing procedures on sewing in YouTube videos in order to jump into the workshop practice efficiently. Of course, input from industry could be invited to keep trainees abreast of the paper pattern manipulating methods.
- TRR_04 replied that a laser washing method (by using less water) on denim could be incorporated into the course, which was common in sustainable development in industry. Indeed, many large brands talked about environmental protection and suppliers along the

supply chain were requested to follow the suit.

In the **question 12**, interviewees were asked about any negative impact from STEM activities received so far, and below were their responses.

• TRR_01 reported the negative impact was quite like the aforementioned constraints, management support, industry collaboration, and relative resources were the utmost essential. In the VR project, TRR_02 mentioned other extra support when convened in other specific sites, manpower resources needed to be enough to drive the project on, and that was not really a negative impact. In fact, there was no negative impact, and STEM activities were important to arouse trainees' interest through the methodology in teaching.

• TRR_02 replied that there was no negative impact heard from this moment.

• TRR_03 responded that there were two types of trainees, the first type consisted of strong and initiative trainees, whilst the second type was reluctant and slow in learning. Therefore, instructors should learn how to engage both types of trainees in the workshop with a limited timeslot during delivery.

• TRR_04 said no but needed to pay attention to the costing area. The maintenance and repairing costs on facilities might be huge to sustain the industry.

In the **question 13**, interviewees were asked whether or not STEM activities would be able to enhance trainees from TVET's knowledge and skill competence basis to meet the challenging sustainable industry in the 21st Century, and below were their responses.

TRR_01agreed on the fashion side, design students ought to know science in order to understand the dyeing process in textiles. Besides that, they also needed to know the materials of nature as well as the chemistry behind them. Since textile required science knowledge to work, henceforth, STEM has to be enhanced.

• TRR_02 agreed and supplemented 3D software which was new and vital in the trend. She believed many garment companies would adopt 3D garment software within 3 to 5 years.

Per her teaching experience, people from the industry and secondary school students have an awareness on what was new in the market.

- TRR_03 agreed that could enhance trainees' knowledge and skill to meet the sustainable industry. There is motivation to learn new things for improvement in a competitive world.
- TRR_04 absolutely agreed.

In the **question 14**, interviewees were asked about any important information missed out in the interview or additional comment, and below were their responses.

- TRR_01 mentioned STEM activity needed to be defined, understood and committed as well as focused in project-based learning which allowed trainees to try on, experiment, and apply the knowledge learnt that was totally different in the past (only instructional PowerPoint and craft-based learning).
- TRR_02 has no other comment.
- TRR_03 said it was good to do more hands-on works, and to go out or exchange with other countries trainees in learning to broaden the scope of vision on new things in the world.
- TRR_04 responded that should have more synergy with industry, and the textile and clothing training courses could be opened to the general public like people from the business field rather than limited to garment companies which seemed to be the gap.

Since only VTC possessed that kind of practical training which could hardly be found in the HK PolyU. Therefore, it was vital to pay more attention to the market needs and customer pool and push the garment technology course thereon.

Section 3. Focus group of Trainee representatives in TVET

Section A – Learning attitude on STEM activities in TVET

In the **question 1**, interviewees were asked about whether they thought STEM activities were useful or not in TVET course and reason, and below were their responses.

• TRE_01 replied that it was helpful to have certain extended that allowed trainees on-site to know the heat conductive products (vest + scarf) together with the instructor's delivery that could really enable trainees clearly to how actual product functioning and works.

• TRE_02 agreed and said it was useful as well as helpful as they could see more new things, the technology they learnt could benefit corporates to save up some cost satisfactory as well as help themselves.

• TRE_03 responded positively as there was interaction and experience amongst trainees.

• TRE_04 agreed due to trainees having more in-depth understanding and knew how it worked in a real situation.

• TRE_05 agreed as trainees could know about the new changes in technology and development. Actually, it was good for buyers or technicians who got in touch with many materials and things.

• TRE_06 agreed it was helpful, if somebody had already got some industry experience, then the learning and absorption would be better and faster. For green trainees or people who did not have much knowledge in textile, maybe not so effective during the learning process. TRE_06 was fine for him, and the learning content could enrich his knowledge.

• TRE_07 agreed since that the workshop and STEM activities could enhance trainees' understanding on waterproofness and breathability in wool. Lecture followed by STEM workshop could enhance learning impression. Therefore, she agreed the STEM workshop was necessary.

In the **question 2**, interviewees were asked whether they thought STEM activities were interesting or not and the reason, and below were their responses.

• TRE_01 reflected there must have had interest. If later on, similar courses with real products to demonstrate and allowed trainees to try and experience, then the result would definitely be good with memory enhancement.

- TRE_02 said it was interesting, as through practicing in the STEM workshop, they could learn about the technology which could be applied in their daily life.
- TRE_03 replied positively because it was very playful and enjoyable.
- TRE_04 agreed it was interesting since it enhanced their understanding in technology, especially how heat be generated from products and their further application. During the workshop, besides listening, they could also get in touch and experience those products that provided them with a more explicit view.
- TRE_05 responded positively. As it is comprised of vivid delivery and STEM activities that enhanced in-depth understanding upon trying and experiencing instead of merely listening to the class.
- TRE_06 reported the on-site demonstration was very interesting, only listening to the context would be boring to the audience.
- TRE_07 encouraged STEM pretty much, she usually bought toys regarding STEM for gifts. Nowadays, she supports STEM, it is necessary to be included in the education.

<u>Section B – Participation in the practical workshop</u>

In the **question 3**, interviewees were asked whether they like to participate in STEM activities or not and the reason, and below were their responses.

- TRE_01 answered that he like the course embedded with STEM activities, and thought it was a good feeling during practice and experience as there was a vivid authentic learning process and application.
- TRE_02 liked them because it allowed her to learn and understand more about technology for self-upgrading in the modern society.
- TRE_03 like them because she could really touch and experience the products in the actual learning process.

• TRE_04 replied yes. The workshop enabled them to know the new technological development in the trend. In particular in HKSAR, those kind of knowledge was useful to their job afterwards.

• TRE_05 responded positively as they wanted to learn new things, new technologies, special materials as well as innovative information from outside, henceforth, they showed eagerness to participate.

• TRE_06 mentioned it was depending on the relevancy between the workshop topic and job and whether helpful or not. TRE_06 said the STEM method was good enough for him as well as increase his interest during participation.

• TRE_07 replied that her friend Nicole and herself were fond of the STEM activities, and they would share those knowledge from the workshop to their colleagues when back in the office. And their reaction was good in workshop.

In the **question 4**, interviewees were asked whether they have encountered a problem or difficulty during participation and reason, and below there were their responses.

• TRE_01 reported there not many difficulties. Nowadays in HKSAR, trading and export business were predominant, and there seldom craft and technology industry existed. In general, trainees were focusing on order follow-up matters that were rarely in touch with technology. When they listened and tried the heat conductive and water-proof products, a lot of the queries could be resolved through the STEM activities they experienced.

• TRE_02 reported no difficulty encountered.

• TRE_03 also reported there was no difficulty coming across.

• TRE_04 said he didn't have a difficulty. Since the delivery was clear with detail elaboration, as such, it was easy to master during the workshop.

• TRE_05 basically replied that no problem encountered in the workshop, and the course was good and professional. However, under the outbreak of a social incident which affected the number of participants. Anyway, they received quite a lot of new information about the topic of heat conductive products.

- TRE_06 reported no problem since the delivery was very clear.
- TRE_07 reflected there was no difficulty indeed, since the workshop was simple and direct, and the instructor was able to clearly explain, instruct and coach them by the side during the demonstration as well as activities in the lesson.

Section C – Receptivity of STEM-based activity

In the **question 5**, interviewees were asked about the receptivity of STEM activities in TVET course, and below were their responses.

- TRE_01 thought it was highly acceptable, and trainees were highly enthusiastic to experience those products as well as investigated the technology behind. For instance, they were trying to find out how a portable power bank could enable the garment products to generate heat which seemed fresh and new to them.
- TRE_02 said it was totally acceptable, and it was moving at the same pace in the modern industry.
- TRE_03 also replied good and highly accepted.
- TRE_04 responded positively. Basically, the development in industry was also following that trend, which could definitely be a beneficiary of their works.
- TRE_05 mentioned it was highly acceptable. They were also eager to visit a factory with innovation technologies.
- TRE_06 said he appreciated, since the teaching method involving application which was vivid and vibrant as well as not boring in the workshop.
- TRE_07 said she felt happy and acceptable.

Section D – Overall outcomes and effectiveness in performance

In the **question 6**, interviewees were asked about the expected outcome before participating in the TVET embedded with STEM activities, and below were their responses.

- TRE_01 replied not much expectation. Trainees might just know there have real products to try and experience.
- TRE_02 expected to collect information on STEM to allow self-upgrading
- TRE_03 said no special expectation.
- TRE_04 expected to have deeper understanding in the new technology development. Actually, they were not very clear about the actual practice and operation and area of application in the future jobs.
- TRE_05 only said wanted to know more new things, but not sure what exactly to get with vague information on products as well as didn't know the actual technology and operation behind it.
- TRE_06 responded that he would select a topic directly related to the job, hence, TRE_06 confessed he had interest in participating.
- TRE_07 responded she didn't think of the STEM workshop, rather she thought it was just a normal lecture with PowerPoint and handouts.

In the **question 7**, interviewees were asked whether the course and STEM activities met their expectation or not and the reason, and below were their responses.

- TRE_01 replied most of the expectations were met. They could also be willing to share what they learnt when coming back to office, which could somehow boost the economy and business development anyway.
- TRE_02 agreed the expectation could be met after the course and STEM activities.
- TRE_03 replied that the expectation could be met and knew more about the heat conductive textile and products and application.
- TRE_04 replied positively and meet their expectation accordingly.
- TRE_05 said that after the completion of the course and STEM workshop, they could

understand more and the expectation could be met. Because they get in touch with the real materials and the function behind which would help them in handling, purchasing as well as application when they come across those type of products in their jobs.

• TRE_06 reflected that it was fine because he could learn some knowledge on a new function about wool during the workshop. He has more understanding about the new technology after joining the demonstration and STEM activity. However, he did not expect how and when could the end products successfully be manufactured by companies in the market. Anyway, TRE_06 was satisfied with the STEM workshop.

• TRE_07 agreed it could satisfy her expectation thereafter.

In the **question 8**, interviewees were asked about any overall effectiveness, and below were their responses.

• TRE_01 said it was basically effective. He suggested having a longer period of STEM activities in the future so that they have more time to practice and experience the real products for sharing and discussion.

• TRE_02 agreed it was effective. And satisfied with those activities with a heat-conductive scarf that made her know more things after the workshop.

• TRE_03 said it was pretty good and effective with no other comment.

• TRE_04 agreed it was definitely effective, and all of them got something solid. He wished to have more of those types of workshops which might benefit their works in the industry.

• TRE_05 replied it was highly effective.

• TRE_06 responded that it could help him in the source of knowledge that could reinforce him to apply for the job or develop other new products.

• TRE_07 committed that the functional knowledge acquired could help her job since she got experience to purchase waterproof and breathable materials. Henceforth, it could enhance her understanding and be elaborated to her customers afterwards.

<u>Section E – Views on future development and advancement in STEM-based activity</u>

In the **question 9**, interviewees were asked whether or not they had any new idea for a STEM-based activity to develop and reason, and below were their responses.

- TRE_01 mentioned it would be better to have a semi-deconstructed heat conductive product in the cross section to demonstrate it to trainees on inner mechanism about heat conduction and control so that they could convey a more clear picture to their colleagues when they are back to the company.
- TRE_02 said no new idea at the moment. Only depending on what topic of the workshop and whether to participate for information update.
- TRE_03 replied not really.
- TRE_04 said due to space and facility limitation. It would be better to arrange the activities in a training center which has more advanced facilities and laboratory equipment for better learning and experiencing.
- TRE_05 mentioned that if time allowed, the activities should be designed and let trainees to assemble the product from semi-finished parts, so that they could involve in building up the heat conductive product and clearly know how fabric, electrical wires and power bank worked together for heat generation as a whole.
- TRE_06 has no comment at that moment.
- TRE_07 did not know how to answer it at that moment.

In the **question 10**, interviewees were asked whether there were any areas or aspects for improvement on STEM-based activity, and below were their responses.

- TRE_01 said already, it was better to have semi-deconstructed garment parts and sample to show inner mechanism in order to enrich the learning content with details. As trainees did not have enough chances to visit the factory nowadays, therefore, dismantled products were good for trainees to understand during STEM activities.

• TRE_02 replied more courses and up-to-date information should be arranged for them for continuous feedback on areas of improvement.

• TRE_03 said she had no idea so far since it was fresh to her.

• TRE_04 mentioned there has room to improve at any time, for example, changing the location with more facility support to enhance trainees understanding. Basic theory was fine, the most important thing was the activities with real products and interaction among trainees during the activity. Perhaps an intermediate course could be organized to explain more in detail how battery and sensors worked together in the near future.

• TRE_05 said it was basically fine, and the delivery was very good. However, she wished to have more time on practice for better absorbing power and interest. It was also better to dismantle the products showing the main parts inside as well as let trainees do more hands-on works. That would be more beneficiary to them.

• TRE_06 pointed out in the topic areas. Try to cover more raw materials as audience from textile and clothing might get in touch with many raw materials, such as outdoor, fashion, sports, street wear, etc. All to say, a wider spectrum of topics or raw materials was preferred for industry sharing.

• TRE_07 suggested that it could be more activities and longer duration. The last workshop seemed a bit hurry in which more STEM could be considered next time such as 60% lecture and 40% STEM.

In the **question 11**, interviewees were asked about whether the STEM activities could be able to enhance their knowledge and skill competence basis to meet the challenging sustainable industry in the 21st Century, and below were their responses.

• TRE_01 answered positively and helpful. But theory and real products must be required to work together in a STEM activity in order to enrich trainees' knowledge and impression while learning.

- TRE_02 answered positively and was looking for more STEM courses to update and upgrade their information apart from self-learning on the website.
- TRE_03 also agreed positively and was good to have practice rather than just theory learning.
- TRE_04 agreed that was helpful. If training enhanced with STEM activity, it would also help practitioners in their daily works in a certain extend. Actually, other industries except fashion, textile and clothing also have those kinds of elements in development.
- TRE_05 answered it should be able to do that.
- TRE_06 replied positively.
- TRE_07 agreed it could help.

In the **question 12**, interviewees were asked about any essential information missed out during the interviews, and below were their responses.

- TRE_01 said no.
- TRE_02 answered no at this moment.
- TRE_03 replied no for the time being.
- TRE_04 said no.
- TRE_05 said no as well.
- TRE_06 has no return.
- TRE_07 said she did not know it was STEM before participation, just thought of the ordinary workshop.

Appendix F (Qualitative Analysis from Respondents)

Code		Response/ Comment/ Feedback	SID-No	Map
SDPTSESV				
SS	1	highlighted the industry mode has been changing to the trading mode, and a new retail direction called "New Retail" mode has been emerged	FTC_02	RQ1
	2	the past mode in labor intensive production was changed and shifted to Mainland China and Offshores, trade business became dominant nowadays in HKSAR	FTC_03	RQ1
	3	more competitive in data exchange and strong in design, the new retail mode e-Commerce and sales strategies required big data to support in order to approach the international markets	FTC_01 FTC_02	RQ1
	4	the better English language ability and communication shown by people from HKSAR, hence they have good potential to deal with US and EU customers	FTC_03	RQ1
SW	1	HKSAR was mainly concentrating on design and merchandising sectors instead of textile business	FTC_05	RQ1
SO	1	the FTC business and operation has been relocated from HKSAR to the Mainland China, especially around the Greater Bay areas in recent years	FTC_01 FTC_02	RQ1
	2	employability and mobility in HKSAR was moderate compared to the greater bay areas in Mainland China	FTC_01 FTC_02	RQ1
ST	1	the FTC industry was lacking the right people with skillsets in production technology and quality control	FTC_04	RQ1
DI	1	to focus more training in marketing, e-Commerce and sales channels areas	FTC_01 FTC_02	RQ1
	2	the manpower strength should be emphasized in creative marketing with technical support as well as new retail	FTC_01 FTC_02	RQ1

	3	design and technology were still required fundamental knowledge, skills and technology to backup, thus craft and technical foundation were the capacity needed in the manpower development	FTC_04	RQ1
		there still have demand in retailing, design and merchandising sectors	FTC_05	RQ1
DT	1	required big data to support in order to approach the international markets	FTC_01 FTC_02	RQ1
	2	element of technology was the greater trend for every parties within the industry in the future	FTC_05	RQ1
	3	technologies on big data for marketing, body scanner for garment stores, and 3D CAD software for virtual design have been seen	FTC_05	RQ1
PK	1	a distant gap between practitioners and market knowhow and not familiarized with the Mainland China	FTC_01 FTC_02	RQ1
	2	designers, owing to limited technical knowledge, they could not foresee difficulty that would happen in the production	FTC_04	RQ1
PS	1	noticed there was more bias to theory and less skill practice in the local TVET	FTC_03	RQ1
	2	the actual skills for problem solving exhibited by the practitioners was questionable and reiterated practitioners and management people should need ground skill sets as basis	FTC_03	RQ1
	3	the trade practitioners acted like a messenger, just passing information from customers to factories without reasonable judgement on the validity due to inadequate technical knowledge background	FTC_04	RQ1

TS	1	agreed design and merchandising sectors required technology to backup, such as 2D and 3D CAD software	FTC_04 FTC_05	RQ1
	2	mentioned on 3D scenario through the computer, such as 3D virtual design and fitting, simulation on catwalk show, 3D CAD software, computer cutting bench and CAM system in which TVET was required to incorporate as training facilities similarly adopted in the industry	FTC_01 FTC_03	RQ2
	3	the big data was the all win in STEM	FTC_01 FTC_03	RQ1
	4	the same 3D CAD software in design drawing and paper pattern design process	FTC_05	RQ2
		training on e-Commerce, online paper pattern manipulation as well as simulated 3D garment design	FTC_01	RQ2
TF	1	training deliver to local designers should be embracing market sense and online sales behavior in addition to the design skill sets	FTC_01 FTC_02	RQ1
	2	more external training and actual practice on machineries for more in-depth learning was a must	FTC_03	RQ1
	3	has inadequate resource to drive and push STEM elements in TVET	FTC_04	RQ2-
	4	in-service training could enhance trainees' knowledge and skillsets, such as related training on new machineries, shoes knitting and seamless knitting machines that was definitely do good to the industry	FTC_04 FTC_05	RQ1
		it was essential to include work-integrated learning (WIL) in the curriculum	FTC_03	RQ1
	5	update technologies and facilities were important to cope with the courses	FTC_05	RQ2

SB	1	all of them agreed STEM activities in TVET could somehow benefit the industry. And sustainability in industry depended pretty much on how many new emerging technologies were replacing the old ones	All FTC	RQ2
	2	sales department made use of big data for analysis that helped in marketing and publicity, wearable technologies, 3D scanner for obtaining body measurements in wedding garment design and customization in production would be the trend thereon	FTC_05	RQ2
	3	people have to choose eco-friendly materials and process to work on, and STEM knowledge background was good to justify with reality	FTC_03	RQ2
	4	STEM acted as a tool in teaching methodology to arouse trainees' creativity	FTC_02	RQ2
	5	STEM together with TVET made the SD work and bloom or TVET should encompass STEM as well as SD so as to benefit the industry	FTC_04	RQ3
	6	STEM activities could enlighten trainees in learning or even with better effect if trainees could get in touch with STEM earlier at secondary school.	FTC_05	RQ3
	7	STEM activities were good for trainees, as they could receive actual practice instead of merely theory instruction. During the practical workshop, they could dig out the problems, looking for feasible solution to enhance their understanding in learning experience	TRR_03 TRR_04	RQ3
	8	VR experience was essential to encourage and enhance trainees in the understanding of spinning, dyeing, weaving, finishing on yarns, fabrics and accessories	TRR_01	RQ3
	9	STEM activities were vital and necessary for upskilling. Finally, TRR_04 reported an increment and improvement	TRR_02 TRR_03	RQ3

		on relevant outcome embracing knowledge and skills in STEM	TRR_04	
	10	the workshop comprised of vivid STEM activities that enrich their understanding upon trying and experiencing instead of merely listening in the class	TRE_05	RQ3
SD	1	four elements in STEM were all vital for contemporary society, in particular, technical issues were important for different streams and curricula. And those four elements needed facilities to support, like laboratory to support science and data color system for training	FTC_04	RQ2
	2	All of them committed to explore and incorporate the relevant STEM activities so as to increase the incentive and involvement of the trainees during learning experience	All FTC	RQ2
	3	In fact, there were various kinds and levels of jobs, people have to keep themselves up in the lifelong learning route so as to stay abreast. A non-stop study pathway from technical knowledge to production knowhow and eventually to management level	FTC_04	RQ3
EC	1	TVET should be geared with fundamental technical knowledge and skills or even has to be upskilled to cover and support e-Commerce and retails, product development and production	FTC_01 FTC_02 FTC_03	RQ1
	2	foundation training in TVET should be reinforced in areas of design, merchandising and marketing	FTC_04	RQ1
	3	smart manufacturing, smart inventory and warehouse control and new retail mode have already been practicing in the Mainland China	FTC_02	RQ1
	4	STEM knowledge were just at a moderate level that might not be enough for future needs, especially, 3D software	FTC_01	RQ1-

		and big data were essential for the industry		
	5	agreed the local trainers should have enough STEM knowledge and skills to teach	FTC_03	RQ1
	6	the skills content of people from industry were still low although being the feeders to them	FTC_03	RQ1-
	7	disagreed with that	FTC_05	RQ1-
	8	the mode of survival in industry has to be matched with the ways of 衣, 食, 住, 行 in which big data would be the underneath support	FTC_01	RQ1
	9	TVET should include the ethics and compliance in the environmental sustainability for training	FTC_02	RQ1
	10	STEM was essential elements in TVET since it would help sustainability to a certain extend upon trainees attended on the job training	FTC_04	RQ1
	11	Eco-concept was required in printing and dyeing, and cited an realistic example of recycling project collaborated amongst HKRITA, H&M and The Mills	FTC_05	RQ1
EF	1	All the industry representatives agreed to that	All FTC	RQ1
	2	it was also good for TVET graduates from HKSAR as feeders to the niche technology for the industry	FTC_04	RQ1
	3	industries normally relied on TVET to provide successors to them	FTC_05	RQ1
	4	both the employability and mobility were fine, in particular, the upward mobility depended pretty much on employees' solid performance as well as related further study	FTC_04	RQ1

	5	employability and mobility were all the times there subject to the skill sets and aggressiveness of the employees	FTC_03	RQ1
	6	the willingness of employees to work abroad	FTC_03	RQ1
SP	1	it was positively accepted by the industry and trainees from TVET were equipped with strong ability on skillsets and competence	FTC_01 FTC_02	RQ1
	2	agreed their skills and competence were basically mapped to the industry in principle	FTC_03 FTC_05	RQ1
	3	the recent bloom in STEM, their skills could somehow fill up the gap and map into the industry	FTC_04	RQ1
	4	their fundamental skill sets were enough and satisfactory, and also depended upon their working attitudes, dedication to job as well as their actual ability in workplace	FTC_02 FTC_03 FTC_05	RQ1
SN	1	the acceptance of TVET would be pretty much depending on types of works	FTC_03	RQ1-
	2	not all trainees could map into the industry, and there was a science and technological gap exited among generations as well as lacking practical experience in workplaces to fulfil the demand from market	FTC_01 FTC_02	RQ1-
	3	the satisfaction from employers was just moderate due to incomprehensive training at school. He stressed the training should be more vibrant with flexible application in workplace rather than factual instruction	FTC_01	RQ1-
VI	1	the challenge in costing about the recycling process on air, water and solid wastes was still a vital issue. Technology would still needed to be advanced to lower down those recycling costs	FTC_04	N/A

	2	The key thing was to teach trainees how to learn in the ever changing market and environment	FTC_01	RQ1
	3	emphasizing more on the content of delivery in TVET that should map to the industry and the incorporation of work integrated learning (WIL)	FTC_04 FTC_05	RQ1
	4	should prepare the trainees to reach out to other markets which were more diversified and potential in development	FTC_02	RQ1
	5	Indeed, training ought to train people to aware and avoid problem happen rather than to solve any problem upon happening. To achieve that ability, trainees have to be equipped with good fundamental technical knowledge to foresee and prevent problem happening at an early phase	FTC_03	RQ1
VO	1	the trend of TVET became weaker due to less support from Government of HKSAR	FTC_04	RQ1
	2	Common views from most of the industry representatives were industry support and funding support from Government of HKSAR to purchase hardware and software facilities as well as staff development for TVET instructors	FTC	RQ2
	3	many parents with rooted mindset thought TVET institutions were inferior to the local or overseas Universities	FTC_04	N/A
	4	most of them borne the similar views on how technologies could help in the environmental protection	FTC	RQ1
	5	3D simulation in weaving a fabric could save time, no emission, no transportation and logistics since no real fabric sample was being produced in the process	FTC_01	RQ1
	6	Eco technology like waterless washing in denim, during	FTC_02	RQ1

	the printing and dyeing processes which consumed negligible or even no water that was good in energy saving as well as carbon dioxide footprint control and discharge that supposed to match with the concept of environmental sustainability	FTC_05	
7	skill sets helped in the authentic workplace, but promotion to higher ranks still required the employees demonstrate enough experience together with the management ability	FTC_03	N/A
8	to focus on retail end, then worked backward from the customer market to the sourcing origin. Attention could be pay more in Mainland China and S.E. Asian countries	FTC_02	RQ1
9	TVET received less support from parents	FTC_04	N/A
10	the importance of the provision of update and down to earth STEM resources	FTC_04	RQ1
11	the Government of HKSAR should support and take role in the STEM in TVET in order to meet the challenging sustainable industry in the 21st Century	FTC_03	RQ2
12	nowadays, more graduates from TVET would like to go into retail sector	FTC_03	RQ1
13	have to change the mindsets of general public on contemporary technologies which were totally different from the past requirement or expectation	FTC_04	RQ2
14	fast fashion wasted a lot of resources, and nowadays, people should be reminded to purchase less and discard less to avoid adding burden to the earth	FTC_05	RQ1
15	whether STEM activities be able to enhance trainees from TVET in knowledge and skill competence basis to meet the challenging sustainable industry in 21st Century. All	All FTC	RQ3

		the industry representatives agreed it was positive since trainees from TVET received actual practical training, participation and authentic application to meet the sustainable industry		
IDLOV				
IC	1	人(instructor who know how to teach), 機(machineries and facilities), 物(enough material for practice), 法(methodology in delivery) which were highlighted by an industrialist in HKSAR for implementation	FTC_04	RQ2
	2	chemical science like textile printing and dyeing, engineering like fabric structure and construction, mathematics like calculation in textiles, all those required trainees to carry out experiment by using microscope, burning test or chemical test under the STEM activities to differentiate various types of fibers and their natures	TRR_01	RQ2
	3	it was quite new and creative to combine and infuse STEM with 3D CAD software	TRR_02	RQ2
IM	1	the importance of WIL and collaboration with industry in order to enhance trainees in authentic workplace learning experience	FTC_02	RQ2
	2	to have better chance to pair up with SMEs in providing training	FTC_03	RQ2
	3	Many practical workshops were equipped with machineries, trainees could operate them with the theory support in behind	TRR_01	RQ2
	4	worked hand-in-hand with the industry, since the new things development were much faster occurred in the industry than TVET	TRR_01	RQ2
	5	The implementation involved various parties in different role plays in the STEM activities for learning. Textile instructors provided relevant knowledge and context, IT	TRR_01	RQ2

		engineers were responsible for writing program, industry helped to align site visit for photo and video recording, and finally the whole process could be explained to the in-house trainees in an animated presentation without limitation on time, venue, as well as safety issue concerned		
	6	trainees could be taught and use 3D CAD software to replace the traditional hands-on method to draw paper pattern, cutting of fabric as well as sewing garment. All those could be done from virtual design, virtual paper pattern manipulation, virtual sewing and eventually virtual fitting on an avatar in the computer for immediate sharing and discussion	TRR_02	RQ2
	7	it was helpful to implement the demonstration on hands-on works and coach trainees in the workshop practice as well as leading them in factory visit that would enable them to experience and understand more about the authentic operation in a workplace	TRR_04	RQ2
DR	1	the limitation was coming from support from top management on extra manning and funding resources, as well as the coordination among interdisciplinary staff so as to arrive a mutual benefit and win-win situation	TRR_01	RQ2
	2	limitation on inadequate facilities and resource on trainer, as one trainer might not able to look after a large group of trainees in the practical workshop	TRR_03 TRR_04	RQ2
	3	top management has to be get involved and provide strong support together with professional knowledge from the working parties	TRR_01	RQ2
	4	in-service trainees from different background of design and merchandising could share new ideas and interact among themselves to overcome the shortage of facilities during training	TRR_03	RQ2

	5	to hire more workshop assistants and divided large class into small groups during the delivery	TRR_04	RQ2
	6	funding and advise should be sought from industry to purchase up-to-date facilities and the total cost incurred might be very high	TRR_01	RQ2
	7	costing on STEM activities would be an issue to consider	TRR_04	RQ2-
DF	1	the limitation was mainly in the computer software, since all the virtual processes were set inside the computer, once the computer software failed to work, all the tasks would then cease	TRR_02	RQ2
	2	Moreover, trainees could not smell and touch the virtual fabrics and hence lack of tactile feeling on real textiles	TRR_02	RQ2
	3	instructors from industry could bring the trainees to visit factories, fashion fairs and companies in order to widen their visions	TRR_03	RQ2
	4	As all those machineries and facilities were distributed across various disciplines, henceforth, good sharing and cooperation was required in the full implementation that solve the limitation in location	TRR_01	RQ2
	5	3D software, funding and sponsorship as well as computer facilities in computer room together with paper pattern tools and sewing machines were required for full implementation	TRR_02	RQ2
	6	the full implementation should involve interaction with industry for new machineries purchase as well as funding support	TRR_03	RQ2
	7	solid teaching materials, realistic machineries and	TRR_04	RQ2

		hardware were vital for implementation to enhance trainees learning and understanding in conducting STEM activities during training course		
	8	enough room and space have to be prepared to house facilities like computers and related tools	TRR_01 TRR_02	RQ2
	9	training facilities should be provided by training institutes, because small company usually could not afford those expensive facilities due to costing and limited space concerned	TRR_03 TRR_04	RQ2
LP	1	most of the trainees accepted and appreciated the dynamic approach in STEM activities that allowed them to concentrate more resulted in better retention in class eventually	FTC_03	RQ3
	2	trainees normally demonstrated good participation in the workshop because they felt interest and afresh about the guided exiting activities	All TRR	RQ3
LF	1	good, satisfactory and positive	All FTC	RQ3
		the learning attitudes from part-time or in-service trainees were better as they have interest to acquire new thoughts and methods during learning with STEM activities embedded	FTC_02 FTC_04	RQ3
	2	all of them reflected that trainees accept the STEM activities with interest and positive learning attitude. TRR_01 recalled her experience in the VR project, trainees demonstrated interest and good learning attitude in the STEM workshop and fond of hands-on practical exercise and authentic experience during participation which embraced factory visit, laboratory experiment and VR experience for learning enhancement	All TRR	RQ3
	3	trainees exhibited great interest, receptivity and good	TRR_02	RQ3

		attitude to try and learn and their works were creative		
	4	trainees or practitioners from industry accepted STEM activities and able to feedback what have been learnt in practical hands-on workshop as well as actual experience along the learning process	TRR_04	RQ3
OF	1	All of the trainers were showing positive sign toward the question	All TRR	RQ3
	2	designers from industry could provide feedback and comment on trainees' works so as to meet the industry demand and attained a good outcome	TRR_01	RQ3
	3	their attitudes were fine, more constructive and really enjoyed the learning experience that deepened their memory	TRR_02 TRR_03	RQ3
OE	1	fine and effective for trainees to acquire up-to-date knowledge during practical training, testing, strengthened up the confidence as well as hands-on crafts that matched with the expectation from industry.	All TRR	RQ3
VI	1	STEM activities were fine to short courses lasted for a few days, in view of long term running on all round training, both theory and STEM activities should be in place	TRR_02	RQ3
	2	fashion design students ought to learn science, materials' nature as well as underneath chemistry in order to understand the dyeing process in textiles	TRR_01	RQ3
	3	STEM activities needed to be defined, understood and committed and focused in project-based learning which allowed trainees to try, experiment, and apply the knowledge acquired that was totally different in the past (only instructional PowerPoint and craft oriented learning)	TRR_01	RQ2-

	4	Also, TVET should pay more attention to the market needs, customer pool and drive the garment technology courses thereon	TRR_04	RQ2
VO	1	the training institutes should incorporate facilities for long term purpose as well as sustainable needs which enable trainees to use them frequently thereafter. And sometime, it was hardly to breakdown the overall costing	TRR_03 TRR_04	RQ2
	2	there was sometimes a mixture of trainees from different countries attended the in-service training, they would share out their learning experience on factory and fashion fair visits during peer group learning	TRR_03	RQ3
	3	multi-disciplinary collaboration was essential, like in VR project, engineering students worked with IT students in co-braining and co-learning along the entire process	TRR_01	RQ2
	4	mobile gamification could also motivate students to learn fashion and textile. For instance, an AR program on goat trapping, students could learn about different species of goats as well as their wool types characteristics in a vivid learning atmosphere	TRR_01	RQ2
	5	a virtual fashion design competition could be organized and inviting secondary school students to participate by adopting the 3D CAD software design and realized by an avatar on virtual catwalk show followed by voting online for winner	TRR_02	RQ2
	6	the laser washing method (by using less water) on denim was a common topic in sustainable industry development	TRR_04	N/A
	7	3D software was new and vital in the trend and many garment companies would adopt this soon	TRR_02	RQ2
	8	more hands-on works or trainees exchanged with other	TRR_03	RQ2

	countries to broaden the scope of vision on new things in the world		
9	to have more synergy with industry, training courses could be opened to general public like people from business field to fill up the gap	TRR_04	RQ2
10	whether STEM activities be able to enhance trainees from TVET in knowledge and skill competence basis to meet the challenging sustainable industry in 21st Century. In general, all trainers and instructors agreed and supplemented with positive comments	All TRR	RQ3
UIPDOV			
UK 1	all the seven interviewees agreed positively and helpful to certain extend	All TRE	RQ3
2	it could enable them to learn heat conductive products and recognized the function and working mechanism behind	TRE_01	RQ3
3	could see more new things which would benefit the corporates	TRE_02	RQ3
4	has more in-depth understanding on how heat conductive technologies worked in the real situation	TRE_04	RQ3
5	knew about the new change in the technology that was good for buyers or technicians who were dealing with many materials and things	TRE_05	RQ3
6	the learning content could enrich his knowledge	TRE_06	RQ3
7	the workshop and STEM activities could enhance their learning impression as well as understanding on waterproofness and breathability in wool, she agreed STEM workshop was necessary	TRE_07	RQ3
UA 1	she could apply what has been learnt in the STEM	TRE_02	RQ3

		workshop in the daily life		
	2	it could enhance their understanding in technology on how heat generated from products and further application with a more explicit view	TRE_04	RQ3
	3	it allowed them to understand more on new technology for self-upgrading in the modern society and useful to jobs	TRE_02, TRE_04	RQ3
	4	That was also moving in the same pace in modern industry and beneficiary to their works	TRE_01, TRE_02, TRE_05, TRE_07	RQ3
	5	it could help them in the functional knowledge and enhance the understanding and application in the job as well as other new products development to customers afterward	TRE_07	RQ3
IP	1	all the interviewees rendered positive feedbacks	All TRE	RQ3
	2	the on-site demonstration was very interesting	TRE_06	RQ3
	3	he confessed he has interest during participation	TRE_06	RQ3
IN	1	N/A		RQ3
PL	1	the STEM activities were playful and enjoyable	TRE_03	RQ3
	2	loved the course embedded with STEM activities and felt good during the practice and experience in the authentic learning process and application	TRE_01, TRE_03	RQ3
	3	she and her friend were fond of the STEM activities which enabled them to share those knowledges to their colleagues when back to office	TRE_07	RQ3
PR	1	although STEM method was good enough to increase his	TRE_07	RQ3=

		interest during participation, but it would depend on the relevancy between the workshop topic and the job to determine whether it was helpful or not		
	2	high receptivity and happy in it	TRE_01, TRE_02, TRE_05, TRE_07	RQ3
DP	1	N/A		RQ3
DN	1	All of the trainee representatives reported not many to no difficulty encountered	All TRE	RQ3
OB	1	did not have much expectation before joining the workshop	TRE_03	RQ3-
	2	expected to know more new things and a deeper understanding in new technologies	TRE_04, TRE_05	RQ3
	3	did not know it was STEM before participation, just thought of ordinary workshop with PowerPoint and hand-outs	TRE_07	RQ3-
OA	1	The course was good and professional, the delivery was clear with detail elaboration on new information about the heat conductive products and easy to master during the workshop, and a lot of queries could be resolved through STEM activities	All TRE	RQ3
	2	the workshop was simple and direct, the instructor was able to explain explicitly, instruct and coach them by the side during the demonstration as well as activities	TRE_07	RQ3
	3	all answered positively and willing to share what they have learnt in the workshop when back to the office as it could help them when handling raw materials, purchasing and application when come across with those types of heat conductive products in their jobs	TRE_01, TRE_02, TRE_03, TRE_04, TRE_05	RQ3

	4	it was fine and he could learn some new knowledge on new function, new technology about wool after joining the demonstration and STEM activities with satisfaction	TRE_06	RQ3
	5	there was good experience on interaction amongst trainees	TRE_03	RQ3
	6	her expectation was satisfied	TRE_07	RQ3
	7	agreed it was effective and got something solid on new things	All TRE	RQ3
VI	1	like to have longer period of time in STEM activities in future to practice and experience on the real products for sharing and discussion	TRE_01	RQ3
	2	if possible, activities would be better to arrange in a training center which has more advanced facilities and laboratory equipment for better learning and experiencing	TRE_04	RQ3
	3	better to have semi deconstructed or dismantled garment parts and samples to demonstrate the inner parts mechanism in order to enrich the learning content with details, and also good to have more time on practice as well as hands-on works so as to benefit trainees' absorbing power and understanding during the STEM activities	TRE_01, TRE_05	RQ3
	4	the training venue to be equipped more facilities to support and enhance trainees' understanding	TRE_04	RQ3
	5	more topic areas could be considered and try to cover more raw materials. Since trainees from textile and clothing industry might get in touch with many raw materials related to outdoor sports, fashion, streetwear, etc. Therefore, a wider spectrum on topics or raw materials was preferred for sharing	TRE_06	RQ3

	6	more STEM activities and longer duration could be considered next time, as the last workshop seemed a bit hurry	TRE_07	RQ3
VO	1	encouraged and supported STEM activities in the contemporary education	TRE_07	RQ3
	2	eager to visit factory with innovative technologies as well	TRE_05	RQ3
	3	the teaching method which involving the application, vivid and vibrant that in the workshop	TRE_06	RQ3
	4	it would be better to prepare the heat conductive products in semi-finished parts or deconstructed cross sections to show the inner working mechanism, so that they could involve in assembling the products that clearly knew how fabric, electrical wires and power bank worked together for heat generation and control as a whole, as such, they could convey an explicit picture to their colleagues when back to the company	TRE_01, TRE_05	RQ3
	5	wanted to have more courses with up-to-date information for continuous feedback and improvement	TRE_02	RQ3
	6	Perhaps intermediate courses could be organized to explain more details on how battery and sensors worked together in near future	TRE_04	RQ3
	7	whether the STEM activities could be able to enhance their knowledge and skill competence basis to meet the challenging sustainable industry in 21st Century. All of the trainees agreed it was helpful and positive to the sustainable industry	All TRE	RQ3

Table 17. Qualitative analysis on the response/ comment/ feedback from respondents

Appendix G (Classroom Observation Records and Floor Plan)

Classroom Observation Forms

Treatment Class A

Class Observation Records

	Items	Frequency Records					General Comments / Recommendations
Name of Subject Lecturer/ Instructor							
		Fully	Largely	To some extent	Little	None	
Date: 11/1/2020	**Part A. Instructor**						
	1) Subject matter/ Content						delivered a clear brief on the objectives and content of the workshop, aswell as the flow and time scheduled
Time: 1430 - 1700	To show good command & knowledge of subject matter, demonstrates breath & depth of mastery	✓					
Venue: HKWAIU Room 702							
Subject: Smart Technologies & Thermal Conductive Textiles	2. Organization						
Topic:	2.1 To state clearly objectives, emphasizes main points with appropriate language & speed		✓				
	2.2 Demontrate timing control in lesson & STEM activities	✓					I helped to be the time keeper
		Very often	Often	Sometimes	Rarely	None	
	3. Rapport with trainees						All trainees actively participated in the activities and discussion They raised a lot questions.
	3.1 To encourage trainees' participation in lesson	✓					
	3.2 Posting up questions & interact with trainees	✓					
	3.3 Provide relevant demonstration & lead the STEM activities in class	✓					
	4. Teaching methodology						
	4.1 To adopt appropriate teaching methods,aids materials & ICT to enhance learning experience	✓					Instructor had well prepared samples and specimens for demonstration
	4.2 To engage & interact with trainees in class trainees in the lesson	✓					
		Very often	Often	Sometimes	Rarely	None	
Observer's name:	**Part B. Trainees**						
	5. Performance in lesson	✓					Trainees raised a lot of questions on thermal materials.
	5.1 Trainees listen & show interest to learn during the lesson delivery						
	5.2 Trainees raise questions for more under-standing during lesson	✓					
Mandy Fung							
	6. Performance in STEM activities						
	6.1 Trainees are motivated to participated in the STEM activities set in the lesson	✓					Trainees were freely to try all samples with very good feedback
	6.2 Trainees can collaborate & successfully complete the STEM activities set in the lesson with intended learning outcomes	✓					
	7. Instructor-trainee's interaction						
Observer's signature:	Trainees pay attention to the demonstration & interact with the instructor during activities	✓					Trainees continuously asked questions during the demonstration

Treatment Class B

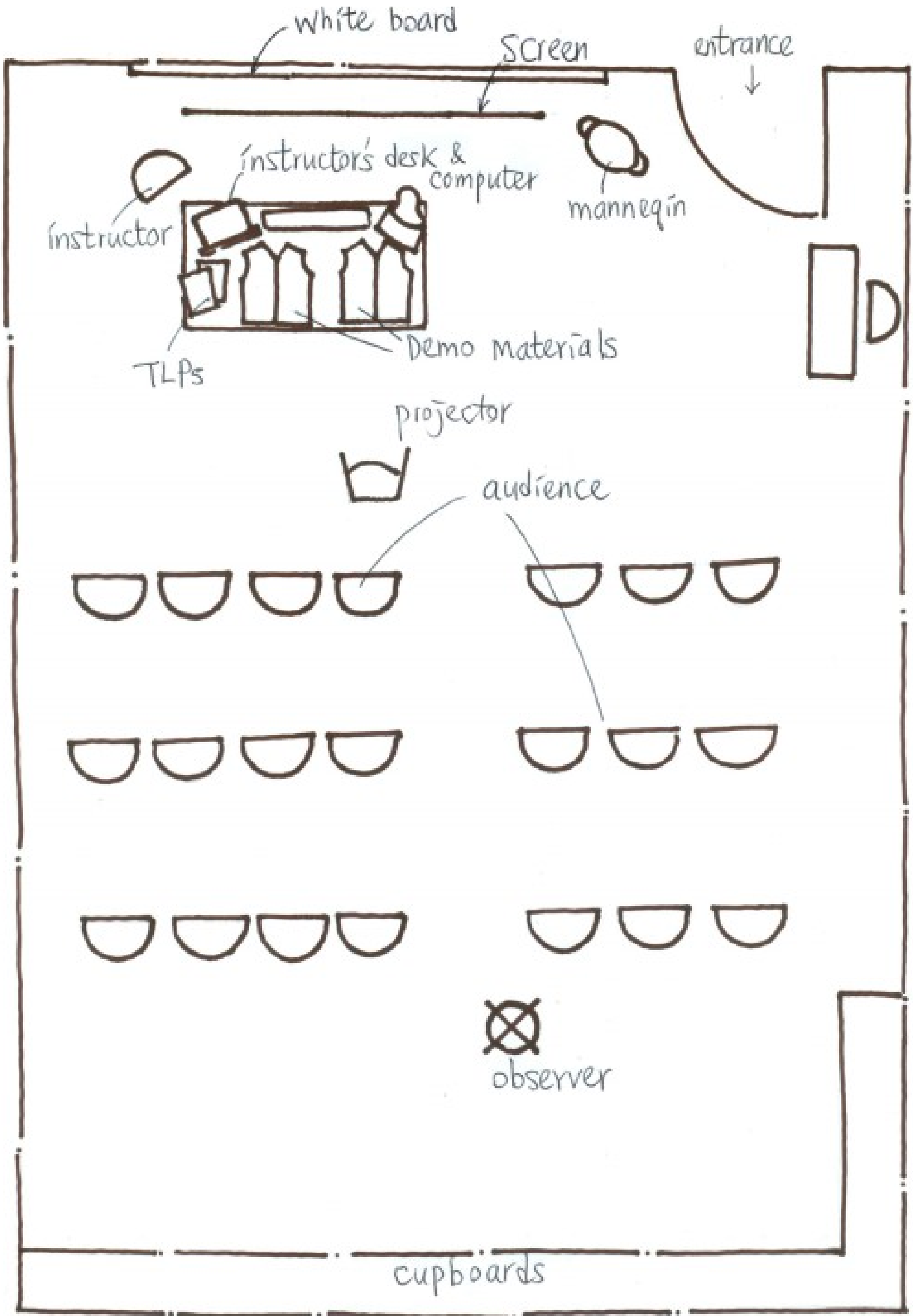
Class Observation Records

Name of Subject Lecturer/ Instructor	Items	Frequency Records					General Comments / Recommendations
		Fully	Largely	To some extent	Little	None	
Date: 29/11/2020 Time: 1430 - 1700 Venue: The Woolmark Company	**Part A. Instructor** 1) Subject matter/ Content To show good command & knowledge of subject matter, demonstrates breath & depth of mastery	✓					Benny had a good preparation of training material & realized the need of the on-job trainees. The content is useful and reachable to most of the on-job trainees.
Subject: Wool for Sports 2019 with Technology Highlights Topic:	2. Organization 2.1 To state clearly objectives, emphasizes main points with appropriate language & speed	✓					The time control is excellent. The trainee had enoug time to think and diggest each session during the traning. Then the trainees had enough time to do the practical trial after the training presentation.
	2.2 Demontrate timing control in lesson & STEM activities	✓					
		Very often	Often	Sometimes	Rarely	None	
	3. Rapport with trainees 3.1 To encourage trainees' participation in lesson		✓				The atmosphere is quite possitive. The trainees are concentrate to the training. Benny had provided some brain storm questions to the trainees and reserved some time slots for the trainee to ask questions. The trainees asked questions proactively. The demonstration is interesting and draw the attention of the traineee as well.
	3.2 Posting up questions & interact with trainees		✓				
	3.3 Provide relevant demonstration & lead the STEM activities in class	✓					
	4. Teaching methodology 4.1 To adopt appropriate teaching methods,aids materials & ICT to enhance learning experience	✓					The teaching technique of Benny is modern, not boring. Well preparated training material, samples, photo, training notes are valueable to the trainees.
	4.2 To engage & interact with trainees in class trainees in the lesson		✓				
		Very often	Often	Sometimes	Rarely	None	
Observer's name:	**Part B. Trainees** 5. Performance in lesson 5.1 Trainees listen & show interest to learn during the lesson delivery		✓				The trainees feel high interest to the training as most of the content are related to their daily job. They had met some similar case previously but might not have a good solution in the old days. The training provided some hints for them. It would be helpful to their career.
	5.2 Trainees raise questions for more under-standing during lesson	✓					
Daniel Chan	6. Performance in STEM activities 6.1 Trainees are motivated to participated in the STEM activities set in the lesson	✓					The trainees enjoyed to do the trial & desmonstration and find out the real meaning behind the practices.
	6.2 Trainees can collaborate & successfully complete the STEM activities set in the lesson with intended learning outcomes		✓				
Observer's signature:	7. Instructor-trainee's interaction Trainees pay attention to the demonstration & interact with the instructor during activities	✓					The trainees are concentrated to the desmonstration and most of them are successful to do the practical trial by themselves.

Treatment Class C

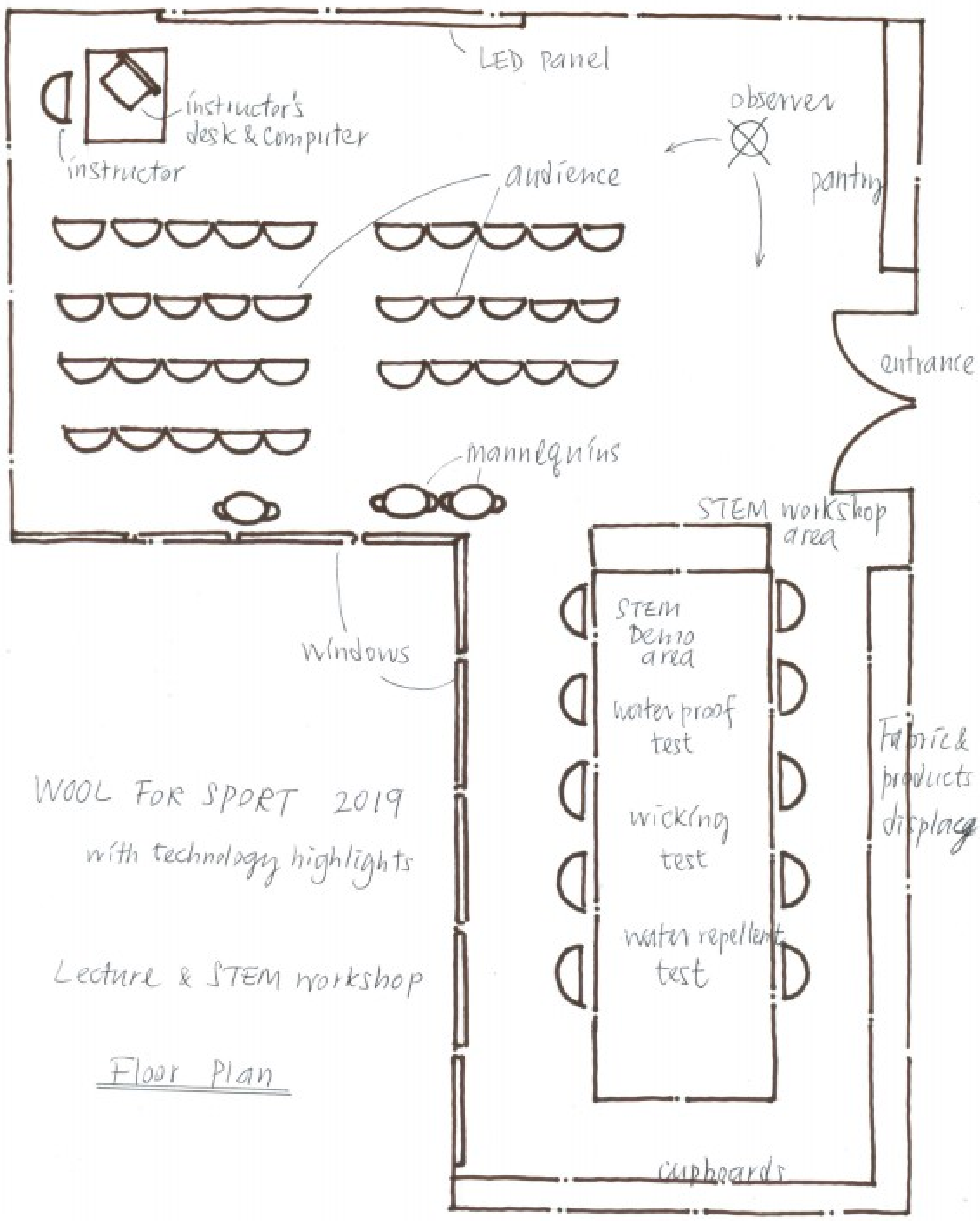
Class Observation Records

Name of Subject Lecturer/ Instructor	Items	Frequency Records					General Comments / Recommendations
		Fully	Largely	To some extent	Little	None	
Date: 27/11/2019 Time: 2050 - 2205 Venue: CITA Room 504	**Part A. Instructor** 1) Subject matter/ Content To show good command & knowledge of subject matter, demonstrates breath & depth of mastery	✓					The instructor has demonstrated good command and profound knowledge in the subject.
Subject: CLO 3D Fashion Software CAD Topic:	2. Organization 2.1 To state clearly objectives, emphasizes main points with appropriate language & speed		✓				She could clearly instruct the trainees to work on the computer software during her demonstration and coaching them in the real practice proactively.
	2.2 Demontrate timing control in lesson & STEM activities	✓					
		Very often	Often	Sometimes	Rarely	None	
	3. Rapport with trainees 3.1 To encourage trainees' participation in lesson		✓				The instructor has interact with trainees by step by step coaching in front of trainee's computer as well as posting and answering questions during her demonstration and trainee's practice.
	3.2 Posting up questions & interact with trainees			✓			
	3.3 Provide relevant demonstration & lead the STEM activities in class		✓				
	4. Teaching methodology 4.1 To adopt appropriate teaching methods,aids materials & ICT to enhance learning experience	✓					With the help from the workshop technician, instructor could able to teach compuer drawing in detials via the 3D CAD software effectively.
	4.2 To engage & interact with trainees in class trainees in the lesson		✓				
		Very often	Often	Sometimes	Rarely	None	
Observer's name:	**Part B. Trainees** 5. Performance in lesson 5.1 Trainees listen & show interest to learn during the lesson delivery	✓					Trainees have paid full attention and show their interest during the lesson. They also often raised the questions and instructor could settle them satisfactory.
	5.2 Trainees raise questions for more under-standing during lesson		✓				
Benny Hwong	6. Performance in STEM activities 6.1 Trainees are motivated to participated in the STEM activities set in the lesson		✓				Under the led and coaching from the instructor, almost all the trainees could complete their virtual garment designs and put them on the avatars for presentation.
	6.2 Trainees can collaborate & successfully complete the STEM activities set in the lesson with intended learning outcomes		✓				
Observer's signature:	7. Instructor-trainee's interaction Trainees pay attention to the demonstration & interact with the instructor during activities	✓					I observed the trainees were fully engaged and showed high interest during the activity.

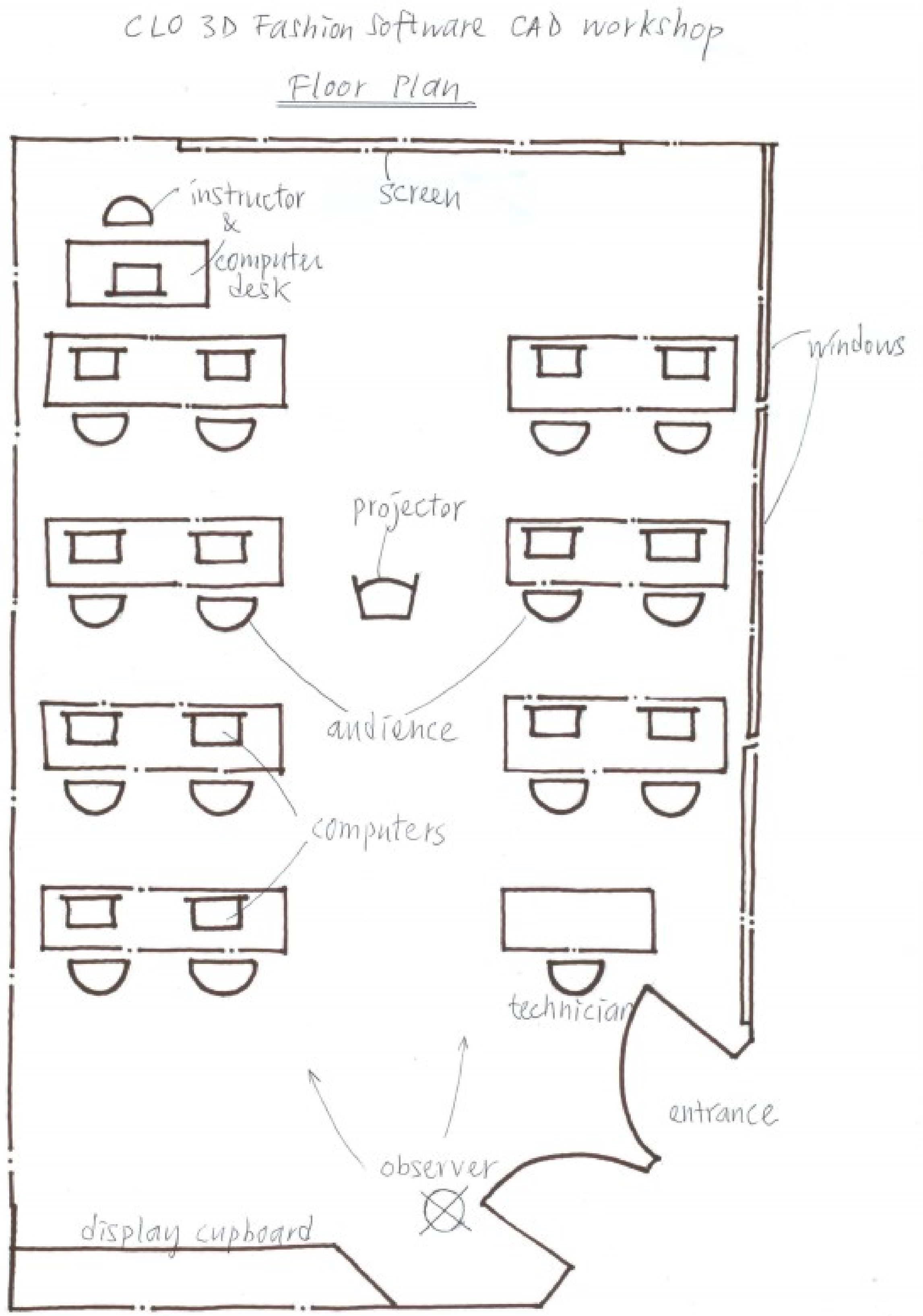


Smart Technologies & Thermal Conductive Textiles

Floor Plan



LED panel
instructor's desk & computer
instructor
observer
audience
pantry
entrance
mannequins
STEM workshop area
windows
STEM Demo area
water proof test
wicking test
water repellent test
Fabric & products display
cupboards
WOOL FOR SPORT 2019
with technology highlights
Lecture & STEM workshop
Floor Plan


CLO 3D Fashion Software CAD workshop
Floor Plan
instructor & computer desk
screen
windows
projector
audience
computers
technician
entrance
observer
display cupboard

Appendix H (Project Briefs of STEM Activities)

PROJECT BRIEF

(STEM activities on thermal conductive textiles/ products)

Objectives : To demonstrate, lead and coach trainees to experience structured STEM activities related to thermal conductive textiles/ products with the aim to enhance their learning outcomes in the TVET training course.

Project : T his is a mini group project that requires trainees to try out and experience on heat conductive textiles or products. To predict what's happen, observe, and analyzes the relevant performance and usage. As a result to propose new design application on functional related end-use products in an outdoor occasion.

Trainees need to predict, observe, analyzes, conclude and propose for new application in the relevant industry.

Assignment : 1) Put on a Virtual Reality (VR) headset
--- slip in a mobile device with an outdoor 360 scenario
--- to simulate an outdoor environment

2) Try and experience on the heat conductive textiles/ products
--- predict what happens before experience
--- observe and analyze the what happens upon trial
--- describe, conclude and propose new design application

Assessment : A group finding and presentation on experimental exercises
30% on prediction on thermal conductive products
30% on observation and analysis
40% on proposal on new end-use product application

END

PROJECT BRIEF

(STEM activities on functional aspects of wool items)

Objectives : To demonstrate, lead and coach trainees to experience structured STEM activities related to functional aspects of wool and wool products with the aim to enhance their learning outcomes in the TVET training course.

Project : T his is a mini group project that requires trainees to carry out and experience a simple test the on water repellent and wicking functions of pre-treated wool and wool products. To observe and compare the similarity against synthetic performance fabrics. As a result to propose new application on functional related end-use products in an outdoor occasion.
Trainees need to observe, analyzes, conclude and propose for new application in the relevant industry.

Assignment : 1) Experimental exercise on Water Repellent
--- drop a small water droplet onto wool fabric/ product provided in the workshop
--- observe and analyze the what happens on the surface of the wool fabric/ product
--- describe, conclude and propose new application
2) Experimental exercise on Wicking
--- drop a small water droplet onto wool fabric/ product provided in the workshop
--- observe and analyze the what happens on the surface of the wool fabric/ product
--- describe, conclude and propose new application

Assessment : A group finding and presentation on experimental exercises
30% on procedures of carrying out of the exercise
30% on observation and analysis
40% on proposal on new end-use product application

END

Appendix I (Teaching Plan/Scheme of Work)

Smart Technologies & Thermal Conductive Textiles (Scheme of Work)

Time Schedule	Teacher Activities	Student Activities	Remarks
1430-1440	1. Brief introduction on the lesson topic and STEM activities	Listening	ppt slide p.1-3
			video-2165
			video-2166
1440-1530	1. Class lecture	Listening	ppt slide p.3-63
	2. Explain what is smart technologies	Viewing the PowerPoint	
	3. What are the STEM elements involved in FTC industry	Raise questions to instructor if appropriate	
	4. Introduce the industrial evolution	Answering questions by random picking students	video-2173
	5. Brief summary on technological insights from ITMA 2019	Watch video	video-2174
	6. Narration on global technological trends	Brainstorming and answering questions	
	-VR, AR, MR, AI, cloud-based computing, smart & wearable	Throwing out ideas	ppt slide p.20
	technology on textile products	Interaction among instructor & trainees	ppt slide p.64
	7. Briefly introduce what is E-textiles		ppt slide p.65
	8. Smart & heat conductive technology on textile products		ppt slide p.66
	- metallic yarn, nano-silver film, carbon nano tube, graphene, etc.		
	- ask questions stipulate in relevant slides		
	- make use of Youtube video to demonstrate the how E-textile works		
	9. Implication & further development on smart technologies		
	10. Question & answer section		digital photo record
1530-1540	Break	Break	Free discussion
1540-1600	1. Demonstration on the heat conductive textiles/ products	Watching the demonstration	Instructor carry out
	- Announce the challenging environmental issues		demonstration in front of
	- Put on the VR headset & slip in the mobile device	Listening	trainee groupings
	- select an 3D 360 view of an outdoor occasion for simulation	Raise questions to instructor if appropriate	
	- Try and experience on heat conductive textiles/ products	Answering questions by random picking students	video-2213
	(direct heat levels control/ mobile apps heat level control)		video-2228
	- Ask trainees to predict what is the result		
			digital photo record
1600-1650	2. STEM activities arranement for trainees	Forming mini groups	ppt slide p.67-69
	- To divide trainees into mini groups of 4-5	Trial and experince on STEM activities	
	- Instruct trainees to follows procedures demonstrated by instructor	Scan the QR code embedded with Project Brief	
	- Guide & allow trainees to try and experience in the activities	Follow the instruction to observe, analyse, describe, conclude	
		and propose new design application under the step by step	
	3. STEM activites Project Brief-worksheet	guidance from instructor	Project-based learning
	- Ask trainees to use their mobile device to scan the QR code which		
	embbeded the worksheet		
	- Remind them to jot down the observation, analyse, discuss and		video-2215
	explain what happen upon trial		video-2216
	- Guide trainees to conclude and propose a new design application in		video-2229
	an outdoor occasion		
			digital photo record
1650-1700	4. Summarize on what was learnt in the lesson & STEM activities	Sharing, discuss & raise questions to instructor if appropriate	Group sharing section
	- Facilitate sharing & discussion in class	Oral presentation from groups	
	- Allow final Q & A	Complete the questionnaire survey	
	- Conduct student questionnaire survey		

Wool for Sports with Technology Highlights (Scheme of Work)

Time Schedule	Teacher Activities	Student Activities	Remarks
1430-1440	1. Brief introduction on the lesson topic and STEM activities	Listening	ppt slide p.1-4
1440-1530	1. Class lecture	Listening	ppt slide p.5-23
	2. Briefly describe the scope of training in vocational eduaction	Viewing the PowerPoint	
	3. Up-to-date technology highlights in ITMA 2019	Raise questions to instructor if appropriate	
	4. Introduce types of animals fibers	Answering questions by random picking students	ppt slide p.24-43
	5. Types of wool, yarn structutre, construction & characteristics	Watch video	
	6. General explanation of wicking & water-repellent textiles	Brainstorming and answering questions	
	-wicking & WR function	Throwing out ideas	
	7. Briefly introduce what is functional merino wool & synthetic fabric	Interaction among instructor & trainees	
	8. How functional meriono wool product & synthetic fabric works		ppt slide p.44-50
	- wool felt cowboy hat, active wear, outerwear, boxer, socks, etc.		
	- ask questions stipulate in relevant slides		
	- make use of video to introduce the wool & wool products		
	9. Implication & further development on functional wool products		
	10.Care & wash information for wool products		ppt slide p.51-53
	11. Question & answer section		
			digital photo record
1530-1540	Break	Break	Free discussion
1540-1600	1. Demonstration on functional performance of wool related products	Watching the demonstration	Instructor carry out
	- Announce the challenging environmental issues		demonstration in front of
	- Testing on the water repellence of wool fabric & products	Listening	trainee groupings
	- Testing on wicking effect of wool fabric & products	Raise questions to instructor if appropriate	
	- Testing on waterproofness of synthetic fabric	Answering questions by random picking students	
	(to compare the performance of both wool & synthetic fabric)		digital photo record
	- Lead trainees step by step to predict, observe & analysis, etc.		
1600-1650	2. STEM activities arranement for trainees	Forming mini groups	ppt slide p.54-57
	- To divide trainees into mini groups of 4-5 people	Trial and experiment on STEM activities	
	- Instruct trainees to follows procedures demonstrated by instructor	Scan the QR code embedded with Project Brief	
	- Guide trainees to try, experiment & take reocrd in the activities	Follow the instruction to observe, analyse, describe, conclude	
		and propose new design application	
	3. STEM activites Project Brief-worksheet	Guide and coach trainees step by step during activities	Project-based learning
	- Ask trainees to use their mobile device to scan the QR code which		
	embbeded the worksheet		
	- Remind them to record down the observation, analyse and explain		digital photo record
	what happen upon trial & experiment		
	- Lead trainees to conclude and propose a new design application in		
	an outdoor occasion under the facilitation from instructor		
1650-1700	4. Summarize on what was learnt in the lesson & STEM activities	Sharing & raise questions to instructor if appropriate	Group sharing session
	- Facilitate sharing & discussion in class	Oral presentation from groups	
	- Allow final Q & A	Complete the questionnaire survey	
	- Conduct student questionnaire survey		

CLO 3D Fashion Software CAD Workshop (Scheme of Work)

Time Schedule	Teacher Activities	Student Activities	Remarks
Lesson 1	1. Brief introduction on the 3D fashion software & scopes of application	Listening to the briefing	PowerPoints
Lesson 2	1. General knowledge about CAD on 3D fashion software	Listening	PowerPoints
	2. Demonstration on 3D fashion software 'CLO'	Viewing the PowerPoint	Demonstration
Lesson 3	1. Class lecture on the usage of 3D fashion software by commercial brands	Listening	PowerPoints
	2. Cite examples of brands which using 3D fashion software	Viewing the PowerPoint & raise questions	
Lesson 4	1. Application on virtual garment design, fitting, visual merchandising, inventory, catwalk presentation, etc.	Raise questions to instructor if appropriate	Demonstration
	2. Example & demonstration for fashion brands & logos	Answering questions posted by the students	
Lesson 5	1. CAD practice on drawing skills (line, coloration, pattern fill, etc.)	Practicing the 3D fashion software individually	3D software practicing
to	2. CAD practice on shapes, silhouette & print pattern designs	Brainstorming and raise questions if appropraite	Guiding & coaching
Lesson 9	3. CAD practice on various types of garment and accessories	Throwing out ideas	
	4. CAD practice on overall garment & outfit design	Exploring & experimenting	
	5. CAD practice on outfit design, fitting & presentation on an Avatar	Peer sharing & interaction	
	Instructor announce the environmental issues & explain how this CAD software can help to rectify in certain extend		
	Instructor & technician guide & coach the trainees step by step in practicing the CAD skills to achieve the outcomes		
Lesson 10	1. Summarize on what was learnt during the CAD workshop	Trainees present their new design on garment & elaborate the details underlying	Presentation & free discussion
	2. Facilitate question & answer section		
	3. Conduct trainee questionnaire survey	Complete the questionnaire survey	

Appendix J (Ethical Approval and Information Sheet)

香港教育大學
The Education University
of Hong Kong

29 January 2019

Mr HWONG Yau Hung Benny
Doctor of Education Programme
Graduate School

Dear Mr Hwong,

<u>Application for Ethical Review <Ref. no. 2018-2019-0208></u>

I am pleased to inform you that approval has been given by the Human Research Ethics Committee (HREC) for your research project:

Project title: STEM Activities in Technical and Vocational Education and Training (TVET) for a Sustainable Fashion Textile and Clothing Industry

Ethical approval is granted for the project period from 1 March 2019 to 30 November 2019. If a project extension is applied for lasting more than 3 months, HREC should be contacted with information regarding the nature of and the reason for the extension. If any substantial changes have been made to the project, a new HREC application will be required.

Please note that you are responsible for informing the HREC in advance of any proposed substantive changes to the research proposal or procedures which may affect the validity of this ethical approval. You will receive separate notification should a fresh approval be required.

Thank you for your kind attention and we wish you well with your research.

Yours sincerely,

[redacted]

Patsy Chung (Ms)
Secretary
Human Research Ethics Committee

c.c. Professor CHOU Kee Lee, Chairperson, Human Research Ethics Committee

香港新界大埔露屏路十號
10 Lo Ping Road, Tai Po, New Territories, Hong Kong
T (852) 2948 8888 F (852) 2948 6000 www.eduhk.hk

香港教育大學
The Education University
of Hong Kong

26 July 2019

Mr HWONG Yau Hung Benny
Doctor of Education Programme
Graduate School

Dear Mr Hwong,

Application for Extension of Ethical Approval <Ref. no. 2018-2019-0208>

I am pleased to inform you that further approval has been given by the Human Research Ethics Committee (HREC) for your research project:

Project title: STEM Activities in Technical and Vocational Education and Training (TVET) for a Sustainable Fashion Textile and Clothing Industry

Ethical approval is granted for the project period from 1 March 2019 to 31 March 2020. If a project extension is applied for lasting more than 3 months, HREC should be contacted with information regarding the nature of and the reason for the extension. If any substantial changes have been made to the project, a new HREC application will be required.

Please note that you are responsible for informing the HREC in advance of any proposed substantive changes to the research proposal or procedures which may affect the validity of this ethical approval. You will receive separate notification should a fresh approval be required.

Thank you for your kind attention and we wish you well with your research.

Yours sincerely,

[redacted]

Patsy Chung (Ms)
Secretary
Human Research Ethics Committee

c.c. Prof CHOU Kee Lee, Chairperson, Human Research Ethics Committee

香港新界大埔露屏路十號
10 Lo Ping Road, Tai Po, New Territories, Hong Kong
T (852) 2948 8888 F (852) 2948 6000 www.eduhk.hk

INFORMATION SHEET

An Action Research on the study of Effectiveness of STEM Activities to enhance TVET for a Sustainable Fashion Textile and Clothing Industry

The Spare Time Study Center of HKFTU, The Hong Kong Wearing Apparel Industry Employees General Union (HKWAIU), The Woolmark Company (TWC) and Clothing Industry Training Authority (CITA) are invited to participate in a project supervised by Prof. Yeung Yau Yuen and Associate Prof. Tsang Yiu Fai and conducted by Hwong Yau Hung who is a doctoral student of the Department of Science and Environmental Studies in the Education University of Hong Kong.

The introduction of the research

The action research study aims to study how STEM activities can enhance the TVET for a sustainable Fashion Textile and Clothing industry. In the 21st Century, the industry has been evolving from traditional labor intensive mode to smart operation with the support from advanced technology in achieving the Eco-concept highlighted in the sustainability, and STEM elements are known as the crucial tools in the TVET to steer and enhance the trainees towards a knowledgeable, skills and competence-based outcomes as well as application in a real-world context. As such, STEM activities related to Fashion and Textile will be designed and implemented in the in-service training courses in the abovementioned organizations. Trainees from the treatment class will be taught and experienced through the STEM activities during the lessons from the period March 2019 to March 2020. Since I am the instructor who will teach and train them throughout the whole course, therefore, the results of the intended learning outcomes can be recorded and evaluated afterwards.

The in-service training courses from them are chosen because they are the most representative with trainees normally coming from various positions and sectors of the Fashion Textile and Clothing industry.

The methodology of the research

There are around 15 students in each in-service training course, and the course is comprised of one to ten lessons with 3 hours per lesson. And the sample size for the research study is around 15 students per class.

The principal investigator will plan the training course outline and contents, prepare the teaching and learning materials, set up STEM activities and evaluation during the research period from March 2019 to March 2020. Structured interviews (around 15 min), class observation (around 1.5 hours) and questionnaires (around 15 min) will be adopted to collect information and data from the treatment class for analysis and improvement action for the second class thereafter.

Within the course, theory and knowledge will be taught prior to the arrangement on the STEM activities, trainees will work individually or as a small group to complete those activities. By doing this, it is hoped trainees can show understand and master the know-how on STEM elements experienced during the course for the real application in the contemporary Fashion Textile and Clothing industry.

This study does not provide individual benefit for the trainees and researcher, but will render precious data for investigating this research topic.

The potential risks of the research

All information related to the trainees will remain confidential, and will be identifiable by codes known only to the researcher. There is no potential risk in this action research.

How results will be potentially disseminated

The quantitative and qualitative data collected and analyzed will be presented in the researcher's doctoral thesis. The result can also be reported in oral presentation to the organization in charge if required.

If you would like to obtain more information about this study, please contact Hwong Yau Hung at telephone number [redacted] or his supervisors at The Education University of Hong Kong.

If you have any concerns about the conduct of this research study, please do not hesitate to contact the Human Research Ethics Committee by email at hrec@eduhk.hk or by mail to Research and Development Office, The Education University of Hong Kong.

Thank you for your interest in participating in this study.

Hwong Yau Hung

Principal Investigator