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Gender stereotyping and STEM education: Girls' empowerment through effective ICT training in Hong Kong

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ABSTRACT

For over a decade, STEM education has been developed as an integrative curriculum for promoting students' performance in the disciplines of science, technology, engineering, and mathematics. However, its development in Hong Kong is still at an early stage, and more studies are necessary to explore the impact of STEM education on local students. In addition, gender stereotyping is a long-standing issue that needs to be addressed in information communications technology ("ICT") education. Through surveys used to evaluate a local ICT training workshop in Hong Kong with 411 female students in junior secondary school, this study provides empirical evidence supporting the effectiveness of a STEM education program for promoting student development and alleviating gender stereotyping in ICT. The results showed that an inquiry-based model of learning, which focuses on students' problem-solving skills and analytical ability, significantly enhanced ICT self-efficacy and reduced perceived difficulties in using ICT. Moreover, ICT-related gender stereotyping was associated with both ICT self-efficacy and perceived difficulties in using ICT, indicating that gender stereotyping in ICT can be reduced by granting more ICT learning opportunities to female students. Although the perceived value of studying ICT did not show a statistically significant improvement as a result of the ICT workshop, perceived value played a critical role in moderating the effect of ICT self-efficacy on ICT-related gender stereotyping and mediated the relationship between perceived difficulties in using ICT and ICT-related gender stereotyping. It is recommended that more emphasis should be placed on promoting perceived values in future ICT programs.

1. Introduction

Originating from the United States, the acronym STEM (science, technology, engineering, and mathematics) has been widely used, particularly in discussions regarding education reform and technology development (Bybee, 2010; Shanahan et al., 2016; Takeuchi et al., 2020; Wong et al., 2016). Given the great importance of technology development to people's everyday life and national competitiveness, more countries have increased their investment in STEM-related industries, such as information technology and engineering (Kennedy & Odell, 2014; Li & Chiang, 2019; Takeuchi et al., 2020). To nurture and develop talents for such industries, STEM education is indispensable (Education Week, 2008). Although studies on STEM education have long been developed in the United States, its effectiveness in countries that have recently begun developing STEM education, such as Hong Kong, is still under-researched (Lee et al., 2019). Moreover, STEM subjects and the ICT field are usually considered as masculinized domains. Gender stereotyping is widespread in STEM industries and education reducing girls' confidence and interest in ICT and steering them away from ICT education and careers. (Clayton et al., 2009; Ferreira, 2017). This is the aim of the present study to supplement empirical results for the impact of STEM programs which are specifically designed for female students on their personal development as well as their gender stereotyping beliefs.

1.1. STEM education

To understand STEM education, it is essential to address the notion of integration in the design of the curriculum (English, 2016; Kelley & Knowles, 2016; Leung, 2020). In the traditional education curriculum, contents of knowledge are typically compartmentalized into different disciplines, such as physics and chemistry, for students to learn accordingly (Labov et al., 2010). Because teachers only offer knowledge in the particular subject in which they are specialized, students learn fragmented and isolated knowledge from each discipline when exams are separated into different subjects. By contrast, STEM education involves viewing the disciplines of science, technology, engineering, and

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mathematics as an interactive/integrative whole in the process of teaching and learning (Breiner et al., 2012; Havice et al., 2018). Students' organization and construction of knowledge can be facilitated when the contents of knowledge are presented in the way in which students can apply and experience in real world practice (Humphreys et al., 1981; Wells, 2019). Due to the complication of integrating the four disciplines in an authentic manner, views and definition on STEM education still vary despite its escalating global attention (Bybee, 2013; English, 2017). There is no consensus on a simple and single model of STEM education, while different understandings and formats of delivery are still evolving.

One dimension of discussion is to define STEM education on a continuum of integration ranging from disciplinary to transdisciplinary approaches (Burke et al., 2014; Moore & Smith, 2014; Vasquez et al., 2013). The disciplinary approach is more or less a STEM enhanced model where STEM activities/programs or additional science, mathematics, technology, or engineering standalone courses are run separately within each discipline. The multi-disciplinary approach involves making use of more than one or multiple STEM knowledge and concepts which are learned in each discipline to solve complex problems or explain sophisticated phenomena. The continuum progresses to inter-disciplinary and transdisciplinary levels, STEM education is far more than a simple and convenient integration of the four disciplines (STEM Task Force Report, 2014). It emphasizes the integration of the disciplines in the context of real-world challenges and problems. Disciplinary knowledge and skills should not only be taught and learned in separation, but also in a meaningful integration. It is argued as an integrated STEM education model integrating multiple STEM concepts to inquire and solve the real-world societal problems in an innovative and creative manner. Students' learning can also be enhanced by linking the four disciplines with their everyday life practice.

Kelley & Knowles (2016) employs a pulley system which is a block and tackle of four pulleys (the four STEM disciplines) with a rope lifting a load (situated STEM learning) by a community of practice (groups of people, such as teachers, students, or related experts, who engage and interact with each other to work on a topic/a set of problems) as a metaphor to develop an integrated STEM education conceptual framework. It means that, more than merely curriculum integration, STEM education is teaching and learning of science and mathematics in a situated manner with concerted efforts from groups of community partners to tackle certain real-world and contextual problems through the practices of scientific inquiry, and the infusion of engineering and technology design, and mathematical analysis. Students are allowed to learn by doing and inquiry. They can learn and make use of technological knowledge and skills to create and conduct experiments verifying the possibilities of different solutions. In the process, students can accumulate their experience and construct new knowledge and understanding through scientific investigation.

Further to Kelley & Knowles' (2016) integrated STEM education conceptual framework, Leung (2020) moves forward to develop a boundary crossing framework for the four disciplines of STEM education. Echoing with Li et al. (2019) and Priemer et al. (2019), Leung (2020) emphasizes that problem solving plays a central role in STEM education. Therefore, STEM education is usually a situated learning in the context of problem solving, which is the core focus to organize boundary crossing among different disciplines throughout the learning process. Building upon an inquiry-based and problem-solving approach of STEM education, Leung (2020, p.5) conceptualizes STEM education as "situated contextual teaching and learning where participants from educational Communities of Practice (e.g. teachers, students) socially co-construct solutions and knowledge for addressing relevant real-world problems through boundary crossing dialogical and problem-solving processes that involve more than one STEM discipline". STEM education is driven by the global challenges such as climate change, health & medical issues, ageing population, shortage of energy and water that require integrated and interdisciplinary solutions (Gao et al., 2020; Kelley & Knowles, 2016). Therefore, it involves more than simply adding an extra computer science class to the standard school or training teachers to make use of the latest digital tools and technology. It is a process of inquiry educating students as problem solvers with critical and analytical thinking to find innovative and creative answers themselves in the natural and man-made world.

To get optimal impact of STEM education and truly prepare students for the real world problems, a different approach of teaching where students can offer and argue with evidence, hear different points of view and discern which seem reasonable, interact and communicate newly created ideas is important. Teachers may need considerable support to build their capacity to deliver integrated STEM instruction (Stohlmann et al., 2012). Teacher training programs may also need to have transformation to reflect this integrated approach of education. STEM education is not a new stand-alone subject in schools as it is practically impossible to create new "integrated STEM education" licensure regulations to recognize and train teachers with sufficient expertise to teach all four disciplines effectively (Sanders, 2008). As a result, developing STEM education involves a collective effort of diverse stakeholders (a Community of Practice), from the education bureau to frontline teaching staff and new kinds of expert partners, to design curricula and develop programs that effectively promote students' interest and performance in the STEM disciplines.

1.2. Learning approaches and inquiry-based model

Regardless of STEM or non-STEM education, its effectiveness is undoubtedly important for all education providers. To raise student learning to the optimal level, we can understand human learning from three perspectives, namely behaviorism, cognitivism, and constructivism (Ertmer & Newby, 2013; Kay & Kibble, 2016; Khalil & Elkhider, 2016). First, behaviorism sees learning as the acquisition of new behavior (Khalil & Elkhider, 2016). It suggests that students learn by changing their behaviors according to their teachers' feedback. According to Skinner's Operant Conditioning Mechanisms, which is an influential behaviorist theory, the rewards and punishments students receive from teachers reinforce their behaviors. Under repetitive practice and training, students tend to act in accordance with the instructions provided by their teachers (Good & Brophy, 1990). Second, cognitivism perceives learning as the acquisition and reorganization of cognitive structures (Khalil & Elkhider, 2016). Compared to behaviorism, cognitivism focuses on the significance of mental activities in human learning behaviors, rather than relying on positive and negative reinforcements. In cognitive psychology, "schemata" refers to the unit of knowledge, understanding, and skills stored in one's long-term memory. These units, "schemas," are massive in number and connect with each other in a logical manner to form memories. New schemas are created and existing schemas are updated when individuals are exposed to new environments. To consolidate memories, students need to grant meanings to the newly acquired information so that the new schemas can then be connected and organized with existing schemas (Clark, 2018). The philosophical assumptions in both behaviorism and cognitivism are mainly objectivistic, while constructivism suggests that individuals build their unique realities based on personal experiences. Thus, on one hand, constructivism views learning as a process of meaning construction through which individuals build their understanding and interpretations of the world (Khalil & Elkhider, 2016); on the other hand, constructivism perceives knowledge as the meanings created and constructed by people in the learning process instead of pieces of information transferred from the external world into the mind (Jonassen, 1991). Therefore, constructivist learning should be situated in real world settings so that students experience and experiment in the learning process.

Obviously, STEM education is consistent with the constructivist human learning perspective as an inquiry-based teaching and learning approach (Kay & Kibble, 2016). Students are encouraged to work independently or interdependently to reflect and develop their own interpretation from the learning process while teachers are the facilitators of their learning (De Jong & Van Joolingen, 1998; Freeman et al., 2014; Pedaste et al., 2015). They think and act spontaneously like scientists to solve specific problem designed by the program using different STEM knowledge and skills (Crippen & Archambault, 2012). The experience students gained through active experimentation not only can facilitate their interpretation and understanding of their own reality, but also shape their affective feelings and emotions, such as interest, attitudes, motivation, and values, toward STEM (Kim, 2016; Schellinger et al., 2019). As a consequence, inquiry-based teaching and learning could be effective to improve student learning of both science concepts and scientific practices (Marshall et al., 2017).

Pedaste et al. (2015) develops a synthesized inquiry-based learning framework with five phrases. The first phrase is an orientation. The learning topic would be introduced by instructors with the major purpose of stimulating students' interest and curiosity (Pedaste et al., 2015; Scanlon et al., 2011). It follows with the conceptualization phase, in which students are exposed to important concepts and form the research questions and hypothesis to the stated problem (Mäeots et al., 2008; Pedaste et al., 2015). After that, they start the investigation phase. Through exploration, experimentation, data analysis and interpretation, they gain hands-on experience in testing and obtaining data to solve the problem (Bruce & Casey, 2012; Pedaste et al., 2015; Scanlon et al., 2011). Getting through all these stages, it ends up with the phase of conclusion. Students can draw conclusion from the data and come up with solutions for the stated problem (Pedaste et al., 2015; Scanlon et al., 2011; White et al., 1999). The remaining phrase is discussion which has great significance to student learning. Supposedly, it presents at every moment and links all phrases together as students learn through constant communication and reflection. This inquiry-based learning framework had inspired the program design of the present study.

1.3. Conceptualization of the study

To promote the development of integrated STEM education, empirical support for its impact and effectiveness is crucially important. However, Lee et al. (2019) finds that the majority (65%) of studies on the topic have been conducted in the United States. Only 8.5% of the studies have been conducted in Asian countries, such as China, Korea, and Malaysia. The lack of research on STEM education can be ascribed to the early development of STEM in these regions. Previous studies reveal that STEM education, compared to the traditional curriculum, promotes greater learning outcomes in different aspects, such as academic performance, creativity, learning motivation, problem-solving skills, and integration skills (Freeman et al., 2014; Liu et al., 2014; Lou et al., 2011). However, it has been suggested that outcomes can vary across nations due to differences in education systems and cultural backgrounds (Marginson et al., 2013). Compared to the United States, where STEM education was initiated in the early 2000s, Hong Kong is still at an early stage of developing a STEM curriculum; the Hong Kong government only recognized the significance of STEM education and decided to enrich the curriculum of the related disciplines in primary and secondary schools in 2015 (Education Bureau, 2016). Despite having a late launch of STEM education in Hong Kong, Hong Kong students have outperformed students from the United States in the recent Program for International Student Assessment (PISA) in STEM-related disciplines (Organisation for Economic Co-operation and Development, 2018). As a city with a unique education system that combines Eastern and Western heritage, Hong Kong deserves more studies that review and evaluate STEM education.

1.3.1. Students' ICT self-efficacy

Self-efficacy is usually referred as a factor of performance, behavior, and academic achievement (Bandura, 1978, 1997; Kelley & Knowles, 2016). To test the effectiveness of STEM education in Hong Kong, the present study uses self-efficacy as the research framework. According to Bandura (2010), self-efficacy is defined as the individual belief about one's ability to achieve a designated level of performance. Self-efficacy influences people's feelings, thoughts, motivations, and behaviors. A strong sense of self-efficacy tends to facilitate one's accomplishments and well-being because individuals with high self-appraisal of their capabilities tend to view difficult tasks as challenges to be overcome rather than threats to be avoided. This perspective allows them to perceive failure as deficiencies of knowledge and skills that must be fostered to achieve future success. People with high self-efficacy, therefore, are more proactive and positive when facing failure, which tends to lead to increased personal accomplishments. For example, students' self-efficacy has been found as significantly related to academic performance (Chemers et al., 2001; Choi, 2005; Lent et al., 1986). Other studies have supported this finding with respect to particular disciplines, including languages (Mills et al., 2007; Woodrow, 2011), mathematics (Pampaka et al., 2011), and science (Larson et al., 2015). Similarly, in ICT education—a new discipline in the current curriculum—a positive correlation between students' ICT self-efficacy and their abilities in managing ICT technologies is also expected. While self-efficacy refers to the individual's confidence in specific areas, ICT self-efficacy particularly addresses the self-perception of capacities in managing software and the internet with specific computer skills and knowledge (Compeau & Higgins, 1995; Fraillon et al., 2013; Murphy et al., 1989). Previous studies have shown that a high level of ICT self-efficacy enhances users' learning effectiveness when using computers as well as achievement in computer and information literacy (Moos & Azevedo, 2009; Rohatgi et al., 2016; Wan et al., 2008). The level of ICT self-efficacy also predicts their motivation in choosing ICT as intended profession (Stewart et al., 2020). In this study, students' ICT self-efficacy and its relationship with other variables will be examined.

1.3.2. ICT gender stereotyping

Along with technology development all over the world, STEM and ICT such as the Internet, big data, artificial intelligence, mobile communication applications, and different types of social media have integrated into people's everyday life and transformed our society. However, gender imbalance with low women's participation is still prevalent in ICT study and career (Castaño, Lubiano, & García-Izquierdo, 2020; Segovia-Pérez, Castro Núñez, Santero Sánchez, & Laguna Sánchez, 2019; Vekiri, 2013). According to European Commission (2018), tertiary graduates in ICT fields accounted for 3.6% of all graduates, only 19% out of which were women in 2015. In the professional sphere, around 16.1% were women out of all ICT specialist workers in European countries. Although there are variations among countries based on different economic and social contexts, the gap is obvious. In Australia, only 26.3% of year 12 girls enrolled in ICT related subjects compared to 39.4% of year 12 boys in 2017. Less than 15% undergraduate female students completed engineering and ICT related courses in 2016. Out of the qualified STEM population, only 17% were women. In engineering, women only represented 12.4% of the workforce. Among the personnel in higher positions, women only made up of 28% in ICT related industries in 2017. All these situations also contributed to a gender pay gap ranging from 11% to 20% in ICT related careers (Commonwealth of Australia, 2019). Similar situation also happens in Hong Kong. Grade 12 female students enrolled in STEM related subjects, physics, software development in the Hong Kong Diploma of Secondary Education Examination in 2019 comprised 30%, 28% and 16.2% respectively (Hong Kong Examinations and Assessment Authority, 2020). Female labors participated in information and communications industry in 2019 were 41,500, while males were more than double with 92,400 (Census and Statistics Department, 2020).

Factors leading to the gender imbalance in STEM and ICT related study and career are complicated and diversified due to the unique situations of each country. However, gender stereotypes treating either men or women as more ideal and appropriate of having certain behaviors or participating in certain activities are often considered as most pronounced obstacles restraining women's access to the sector (Castaño et al., 2020; Segovia-Perez et al., 2019, Vekiri, 2013). For example, the ICT industry, where employees need strong mathematical and logical skills, is often considered to be male-dominated (Gürer & Camp, 2001; Herring et al., 2006; Newmarch et al., 2000). Women are then perceived as less capable of managing ICT and tend to develop lower self-esteem and interest than men (Bandura, 2010; Berg et al., 2018; Clayton et al., 2009; Gürer & Camp, 2001; Hawkins et al., 2019). In recent years, some studies found that even some girls could catch up with or even surpass boys in science and mathematics and outperform boys in digital and engineering subjects, they did not plan or even decided not entering into ICT field because they perceived themselves as not interested or intelligent enough or they still had the thoughts that technology related careers should be taken up by men (Kelan, 2007; Mumporeze & Prieler, 2017; Vekiri, 2013). Therefore, young people's academic choices and career aspirations are determined not only by their actual abilities, but also their subjective beliefs and perceptions shaped by their learning experiences or gender stereotypical roles expected in the socialization process. To release and develop female students' untapped potential for the industry, the present study is interested in further exploring the impact of STEM education on alleviating gender stereotyping in ICT education.

1.4. The program of the present study

The present STEM education program was an extracurricular activity offered by a NGO in Hong Kong targeting female students in Grades 7 or 8. Bearing the conceptual framework of integrated STEM education in mind, the program was purposefully designed with an inquiry-based model nurturing female students not only with ICT skills and knowledge, but also as critical problem solvers handling a designated STEM project with their innovation and creation. First of all, the program included a three-day ICT training workshop. The students were orientated to the design of the program and the interesting functions of using micro:bit coding to control various kinds of real life devices, such as game controllers or LED light ribbons. This aimed to raise students' interest in the technology and understanding on its linkage with real-life applications. After that, the basic concepts of micro:bit and its coding and programming language were taught. Allowing students to develop their innovation and creativity to apply their knowledge and skills in coding different LED light patterns, they were divided into small groups to produce wearable items, such as sweaters, shoes, hats or other accessories, with LED light ribbons. At the end, to conclude their learning through the workshop, a mini fashion show was arranged. On the one hand, students were required to present and introduce the design of their wearable items with PowerPoint. At the same time, they need to demonstrate their products with catwalks in the mini fashion show.

After the first part of training, students joined another two half-day online video-making workshop learning to promote their wearable products with online video to all students of their schools. In this way, more students could taste the interesting functions and applications of technology. The third part of the training were a series of company visits cum ICT career talks. Successful female role models in the technology industry were invited to share their experience and insights with the students. The students were then exposed to the new perspectives and contributions where females can make in STEM and ICT field. The program included a series of activities to develop female students' interest and untapped abilities in science and technology. Through the learning by problem solving, co-construction, and inquiry processes, not only students' self-efficacy in managing the technical knowledge and skills in ICT, but also their personal capacity in problem solving, system thinking, and affective feelings, such as their interest, attitudes, motivation and values, towards ICT could also be enhanced.

1.5. Hypotheses of the study

To investigate how STEM education impacts female students' ICT self-efficacy and their gender stereotyping, the present study proposes four hypotheses assessing the relationship of different variables. First, as mentioned, STEM education is a process of inquiry not only to enhance people's ICT self-efficacy, but also educate them as problem solvers with critical and analytical thinking to find innovative and creative answers in their everyday practice. Among the literature, there is still a lack of research on the effect of problem-solving skills and analytical ability on students' ICT self-efficacy. However, previous studies on teachers' performance have shown that improvement of ICT problem-solving skills can enhance computer competence and reduce techno-anxiety (Revilla Muñoz et al., 2017). Moos and Azevedo (2009) also indicates that personal qualities can influence students' learning processes and outcomes. In particular, students with better problem-solving skills and analytical skills tend to have higher achievement in mathematics and sciences (Martin et al., 2012; Politsinsky et al., 2015). Thus, it is believably that students' personal qualities, such as problem-solving skills and analytical skills, can increase ICT self-efficacy and lower perceived difficulties in using ICT.

H_1: Stronger problem-solving skills and analytical ability predict higher ICT self-efficacy and lower perceived difficulties in using ICT.

Second, the present study is interested in the relationship between ICT self-efficacy and attitudes towards studying ICT, including students' interest and perceived value of studying ICT. In a study of US college students enrolled in an online class, Wang and Newlin (2002) found that students who were more curious about the course had a higher ICT self-efficacy and better performance than those who enrolled solely because of class availability. The findings suggest that ICT self-efficacy, interest in studying ICT, and ICT performance are positively correlated with each other. Moreover, other studies have shown that a higher perceived value of subject areas, including language and STEM-related disciplines, can increase students' interest, motivation, and self-efficacy (Bonitz et al., 2010; Mamaril et al., 2016; Mills et al., 2007; Torkzadeh & Van Dyke, 2002). These findings suggest that self-efficacy, interest, and perceived values are positively correlated with each other. Considering the findings from Reese and Miller (2006) indicating that career decision-making courses can increase students' self-efficacy and lower perceived difficulties, the contrast between self-efficacy and perceived difficulties can be reduced, which leads to the second hypothesis of the current study.

H_2: Higher ICT self-efficacy and lower perceived difficulties in using ICT predict higher interest in studying ICT, and thus lead to higher perceived value of studying ICT.

Third, this study intends to address the effect of ICT self-efficacy and perceived value of studying ICT on ICT-related gender stereotyping. Although self-efficacy and gender stereotyping are significant issues in ICT-related studies, there are a limited number of studies exploring the association between these variables. According to Kvasny et al. (2011), self-efficacy, gender stereotypes about IT skills, and the importance of IT skills are three critical factors that influence career choice among college students, regardless of their racial and ethnic backgrounds. However, because they did not conduct correlation analysis in their study, their findings do not provide information on the relationship among these variables. Furthermore, Vekiri and Chronaki (2008) explored the effect of computer experiences, social support for using computers, and motivational beliefs of Greek elementary school students on their computer self-efficacy and value beliefs. They found that girls have lower computer self-efficacy and value beliefs than boys. As gender stereotyping in ICT places female students in a disadvantageous position, the present study is interested in exploring the effect of ICT self-efficacy and perceived value of studying ICT on perceived ICT-related gender stereotyping.

H_3: Perceived value of studying ICT moderates the effect of ICT self-efficacy on ICT-related gender stereotyping.

Fourth, the effect of perceived difficulties and perceived value of ICT on gender stereotyping is addressed by the current study. As mentioned previously, the contrast between self-efficacy and perceived difficulties can be reduced from the study conducted by Reese and Miller (2006). Thus, the fourth hypothesis concerning the effect of perceived difficulties is constructed similar to the third hypothesis.

H_4: Perceived value of studying ICT mediates the effect of perceived difficulties in using ICT on ICT-related gender stereotyping.

At the end, to conclude the effectiveness of the STEM program of this study, the overall effect of the ICT training on each variable is examined. Previous studies indicate that experience using computers is influential to different aspects of student development, such as ICT self-efficacy (Houle, 1996; Rohatgi et al., 2016), ICT attitudes (Broos, 2005), and online class performance (Shany & Nachmias, 2001). The STEM program was purposefully designed with an inquiry-based model nurturing female students' self-efficacy in managing the technical knowledge and skills in ICT, and their personal capacity in problem solving, system thinking, and affective feelings, such as their interest, attitudes, motivation and values. It is reasonably to believe that students will benefit from the ICT training and that a significant change will be observed in all measured variables.

2. Methodology

This study adopted a quantitative approach to explore the relationship among the variables and to assess the effectiveness of a STEM program in Hong Kong. Two-wave questionnaires were conducted before and after a three-day intensive ICT training workshop. The STEM program was specifically designed for female students, ages 12–14 years old, who were enrolled in Grades 7 or 8; it was developed by a charitable NGO in Hong Kong that promotes women's empowerment, specifically to enhance their attitude, perception, and confidence in managing computers and information technology. The baseline (T_0) data was collected from the student participants before the workshop, whereas the post-training questionnaires (T_1) were conducted shortly upon the completion of the training sessions. Both sets of questionnaires used in the study have been reviewed and endorsed by the Research Committee of the affiliated University to assure compliance with ethical standards and procedures. Informed consents were also obtained from the participants and their parents/guardians.

2.1. Participants

A sample of 509 female students from 13 secondary schools in Hong Kong participated in this study via the program launched by the charitable organization. All partnered schools and students joined the program voluntarily. As they were not randomly selected, the representativeness of the sample was not claimed. From the pool of participants, only 411 sets of valid data, of which baseline and post-training data were able to be matched, were collected for further analysis. Specifically, 245 Grade 7 and 166 Grade 8 students were included.

2.2. Measures

In this study, a set of two-wave questionnaires was designed to measure seven variables from the student participants using 7-point Likert Scales (1 = strongly disagree, to 7 = strongly agree). The PISA 2012 assessment (Peña-López, 2012) is a widely recognized ICT-related test. This study referenced it to develop the measures with modifications. To ensure the reliabilities of the measures, a pilot study of 324 female participants from nine secondary schools in Hong Kong was done one year before this study. In the pilot study, all scales were back and forth translated in Chinese, with Cronbach's alpha values ranging from 0.84 to 0.92. In the present study, all measures had high reliability in both pre-test and post-test. The seven measures are detailed below.

Problem-solving skills: The student participants' problem-solving skills were measured by a scale with four items, such as *When I face a problem, I will work with it and seek help actively*. Higher scores indicate a stronger capacity in problem-solving skills. The Cronbach's alpha of this scale was 0.74 in pre-test and 0.92 in post-test, which indicates reliability.

Analytical ability: The student participants' analytical ability was measured by a scale with five items, such as *I will collect relevant information and study the problem thoroughly*. Higher scores indicate a stronger capacity in analytical ability. The Cronbach's alpha of this scale was 0.92 in pre-test and 0.95 in post-test.

ICT self-efficacy: The student participants' self confidence in learning and using computer and information technology was measured by a scale with eight items, such as *I believe I will be able to manage if my future job requires the skills and knowledge of information and communications technology.* Higher scores indicate a higher confidence in learning and using information and communications technology. The Cronbach's alpha of this scale was 0.92 in pre-test and 0.93 in post-test.

Perceived difficulties in using ICT: The student participants' perceived difficulties in managing different ICT tasks were measured by a scale with seven items, such as *It is difficult to change the computer settings to solve a problem or improve the processing.* Lower scores indicate less difficulty in using ICT. The Cronbach's alpha of this scale was 0.83 in pre-test and 0.88 in post-test.

Interest in studying ICT: The student participants' interest in studying ICT was measured by a scale with seven items, such as *I like reading books and magazines about computer and information technology.* Higher scores indicate a higher interest in studying ICT. The Cronbach's alpha of this scale was 0.86 in pre-test and 0.88 in post-test.

Perceived value of studying ICT: Taking reference from Chow et al. (2012), the student participants' general perception about the value of studying ICT was measured with five items, such as *I think learning knowledge and skills related to information and communications technology is very useful.* This scale examined students' subjective value of ICT in terms of importance, usefulness, and level of interest in technology and coding. Higher scores indicate a higher perceived value of studying ICT. The Cronbach's alpha of this scale was 0.83 in pre-test and 0.93 in post-test.

Gender Stereotyping in ICT: The student participants' gender-stereotypical beliefs on using information and communications technology were measured by a scale with four items such as *I think that in the field of science and technology, men have natural advantages.* Higher scores indicate higher perceptions of gender stereotypes. The Cronbach's alpha of this scale was 0.94 in pre-test and 0.95 in post-test.

The measures developed in this study were mainly modified from the PISA 2012 assessment with a pilot test. To make sure that the scales constructed are discrete and robust measuring the variables as designed, a principal component analysis with the oblimin rotation was performed over the 42 measured items initially for the purpose of dimensionality reduction. By applying the Kaiser rule in selecting the number of components, two items, one from the scale of problem-solving skills and the other one from the perceived difficulties in using ICT, did not contribute to a simple factor structure and thus being removed. The remaining 40 items were discretely categorized under seven factors, while factor IV relating to the student participants' perceived difficulties in using ICT were divided into two sub-scales: IVa of simple tasks, and IVb of complicated tasks. To ensure the unidimensionality of each scale in measuring the constructs, principle components analyses were run again for each scale. The results showed that strong unidimensionality is observed in all scales (see Table 1).

2.3. Data analysis

The collected data were processed and analyzed using the statistical software of SPSS version 26. Pearson's correlation test was conducted to measure the strength of correlation among all variables. Next, regression analysis was used to test H_1, H_2, $H_{3,}$ and H_4. The PROCESS analysis

Table 1
Principal component analysis of the scales.

	Item loading	Eigen value	Cu. %	Cronbach α Pre-test	Cronbach α Post-test
(I) Problem-solving skills		**2.62**	**52.39**	**0.74**	**0.92**
1a. When I encounter a complicated problem, I know how to solve it systematically	0.78				
1b. When I face a problem, I will work with it and seek help actively	0.80				
1c. When I face a problem, I will assess the pros and cons of all possible alternatives	0.81				
1d. After solving a problem, I will reflect and consolidate the experience gained in the process	0.78				
(II) Analytical ability		**3.78**	**75.54**	**0.92**	**0.95**
When you encounter a problem, what would you do?					
2a. I can analyse it calmly and solve it step by step	0.85				
2b. I will collect relevant information and study the problem thoroughly	0.86				
2c. I can analyse the problem and explore possible ways out	0.91				
2d. I can usually think of more than one solution	0.83				
2e. I will make decision with enough information and analysis	0.89				
(III) Self-efficacy in ICT		**5.12**	**64.02**	**0.92**	**0.93**
3a. I am confident in completing the homework of the Information and Communication Technology subject.	0.79				
3b. To me, it is not difficult at all to learn computer application and information technology.	0.82				
3c. If I work harder, I believe I can have better result in the Information and Communication Technology subject.	0.68				
3d. To me, the Information and Communication Technology subject is not difficult.	0.85				
3e. I expect good result in my Information and Communication Technology subject next year.	0.80				
	0.84				
3f. I believe I will be able to manage if my future job requires the skills and knowledge of computer or information technology.					
3g. When people come across problem in using computer, I can usually give suggestion or offer help.	0.79				
3h. I do not need to pay too much effort to fulfil the curriculum requirement in studying the Information and Communication Technology subject	0.81				
(IV) Perceived difficulties in using ICT			**75.05**	**0.83**	**0.88**
(IVa) Simple tasks		**3.51**		**0.84**	**0.94**
4a. Search and find the document I want in the computer	0.89				
4b. Open and edit a Word document with a computer (e.g. for school works)	0.85				
4c. Search and find useful information through the internet	0.87				
(IVb) Complicated tasks		**1.74**		**0.86**	**0.91**
4d. Create a webpage	0.80				
4e. Change the computer settings to solve a problem or improve the processing	0.81				
4f. Develop a simple computer programme	0.87				
4g. Establish a computer network	0.89				
(V) Interest in studying ICT		**4.43**	**55.32**	**0.86**	**0.88**
5a. I enjoy learning computer and information technology.	0.84				
5b. To me, the learning of computer and information technology is interesting.	0.85				
5c. I like reading books and magazines about computer and information technology.	0.77				
5d. I am happy when I can solve problem making use of computer and information technology.	0.72				
5e. I am happy when I learn new skills and knowledge about	0.74				

(*continued on next page*)

Table 1 (*continued*)

	Item loading	Eigen value	Cu. %	Cronbach α Pre-test	Cronbach α Post-test
computer application.					
5f. I am interested in understanding the design principles when I am using a computer programme.	0.81				
5g. When facing a machine, I am interested in learning about its operational principles.	0.79				
(VI) Perceived value of studying ICT		**2.98**	**59.6**	**0.83**	**0.93**
6a. Computer and information technology are closely related to everyday life	0.78				
6b. I think learning the knowledge and skills related to computer and information technology is very useful.	0.84				
6c. Computer and internet are very useful in assisting me to complete my homework.	0.74				
6d. Computer and information technology can improve our living standard.	0.76				
6e. To me, it is worth spending time to learn knowledge and skills related to computer and information technology.	0.74				
(VII) Gender-stereotyping in ICT		**3.27**	**81.68**	**0.94**	**0.95**
7a. Men are naturally more talented than women in the learning of computer and information technology.	0.88				
7b. Women are less capable in logical and analytical thinking than men.	0.89				
7c. In the field of science and technology, men have the natural advantages.	0.93				
7d. Men, rather than women, are more suitable to work in the computer and information technology industry.	0.92				

$N = 411$. Items were rated on a 7-point Likert scale: 1 'strongly disagree' to 7 'strongly agree'.

modeling tool in SPSS was used to determine the mediation and moderation effects between the variables. To conclude the impact of the ICT training workshop, paired sample t-tests were carried out to compare the mean scores obtained before (T_0) and after (T_1) the ICT workshop in each scale.

3. Results

3.1. Correlation test

Pearson's correlation test was computed to investigate the relationship between the variables. As shown in Table 2, all correlation coefficients between variables were above the significance level, indicating that all variables were closely related to each another. Among the seven variables, perceived difficulties in using ICT and ICT-related gender stereotyping were negatively correlated with other variables. For example, self-efficacy in ICT was positively correlated with problem-solving skills, analytical ability, interest in studying ICT, and perceived value of studying ICT. This suggests that students with higher self-efficacy in ICT tended to have higher levels of other variables. By contrast, self-efficacy in ICT was negatively correlated with perceived difficulties in using ICT and ICT-related gender stereotyping, implying that students with higher self-efficacy in ICT were more likely to perceive ICT tasks to be less difficult and less masculine. The findings from the correlation test revealed that all variables were highly associated; causal relationships were addressed by regression analysis, as discussed in the following subsection.

3.2. Regression analysis

To test the hypotheses, a series of regression analysis was computed to determine the relationships among the variables. Simple linear model regression, mediation analysis, and moderation analysis were conducted in SPSS. The results are presented below under each corresponding hypothesis.

3.2.1. Hypothesis 1

First, problem-solving skills and analytical ability were influential to self-efficacy in ICT and perceived difficulties in using ICT. The multiple regression results showed that problem-solving skills and analytical ability statistically significantly predicted self-efficacy in ICT ($F(2, 398) = 69.11, p < 0.001, R^2 = 0.26$). Both variables statistically significantly increased the prediction value, $p < 0.01$. Meanwhile, these variables also negatively predicted perceived difficulties in using ICT ($F(2, 389) = 34.66, p < 0.001$, $R^2 = 0.15$). Both problem-solving skills and analytical ability were significant in predicting perceived difficulties, $p < 0.05$. These results indicate that students with higher problem-solving skills and analytical ability tended to have higher self-efficacy in ICT and lower perceived difficulties in using ICT (see Fig. 1).

3.2.2. Hypothesis 2

Regarding H_2, the results from the regression analysis in Fig. 2 show that interest in studying ICT was predicted significantly by self-efficacy in ICT and perceived difficulties in using ICT ($F(2,392) = 156.27$, $p < 0.001$, $R^2 = 0.44$). These variables had contrasting effects on predicting interest in studying ICT: self-efficacy was positively related to interest while perceived difficulties was negatively associated with interest. Furthermore, Fig. 3 illustrates the effect of interest on the perceived value of studying ICT: the level of interest in studying ICT significantly predicted the level of perceived value of studying ICT ($F(1,401) = 250.15$, $p < 0.001$, $R^2 = 0.38$). Students with a higher interest in studying ICT were more likely to perceive a greater value of studying ICT. Thus, students with higher self-efficacy in ICT and lower perceived difficulties in using ICT are predicted to have a higher interest in studying ICT, which further leads to a higher perceived value of studying ICT.

3.2.3. Hypothesis 3

To test whether the association between self-efficacy in ICT and ICT-

Table 2
Zero-order correlation coefficients among variables.

	Problem Solving Skills	Analytical Ability	Self-efficacy	Perceived Difficulties	Interest	Perceived Value	Gender Stereotyping
Problem-Solving Skills	1						
Analytical Ability	0.70***	1					
Self-efficacy in ICT	0.43***	0.50***	1				
Perceived Difficulties in Using ICT	−0.33***	−0.38***	−0.44***	1			
Interest in Studying ICT	0.43***	0.48***	0.66***	−0.34***	1		
Perceived Value in Studying ICT	0.36***	0.36***	0.44***	−0.27***	0.62***	1	
ICT related Gender Stereotyping	−0.18***	−0.14***	−0.18***	0.14**	−0.26***	−0.17**	1
Valid number of sample (N)	407	406	410	400	405	409	411
Mean	4.66	4.83	4.50	3.41	4.95	5.76	3.29
Std. Deviation	0.90	1.05	1.08	1.04	0.93	0.75	1.42

Notes. *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001.

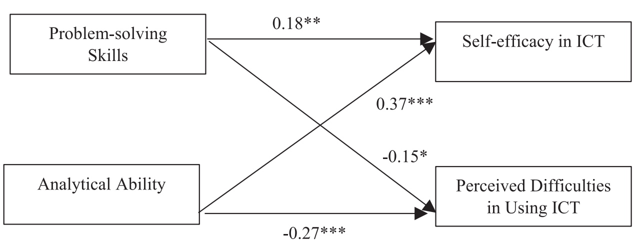

Fig. 1. Regression diagram of effect on self-efficacy in ICT & perceived difficulties in using ICT.

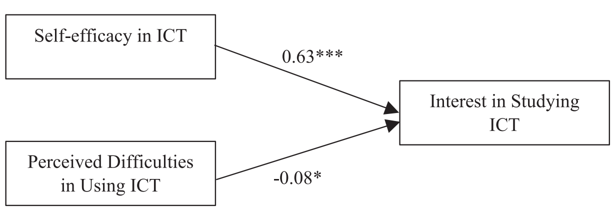

Fig. 2. Regression diagram of effect on interest in studying ICT.

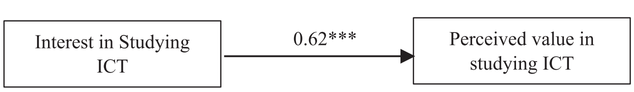

Fig. 3. Regression diagram of effect on perceived value in studying ICT.

related gender stereotyping was affected by the perceived value of studying ICT (H_3), a hierarchical multiple regression analysis was conducted. In the first model, the results showed that self-efficacy and perceived value accounted for ICT-related gender stereotyping, $R^2 = 0.04$, $F(2,405) = 9.08$, $p < 0.001$ (see Table 3). Next, the variables were centered and the interaction term between self-efficacy in ICT and perceived value of studying ICT was added into the regression model. The second model had a significant change compared to the first model, $\Delta R^2 = 0.016$, $\Delta F(1,404) = 6.82$, $p = 0.009$, $b = -0.18$, $t(404) = -2.37$, $p = 0.02$ (see Tables 3 and 4). As shown in Fig. 4, the interaction plot indicated a diminishing effect: as the self-efficacy in ICT and perceived value of studying ICT increased, ICT-related gender stereotyping decreased. At a low level of self-efficacy, students' perceived ICT-related gender stereotyping was similar for students with low, average, and high levels of perceived value of studying ICT. As the level of self-efficacy increased, students with a high perceived value of studying ICT perceived a lower ICT-related gender stereotyping than those with a low perceived value of studying ICT. The perceived value of studying ICT moderated the relationship between self-efficacy in ICT and ICT-related gender stereotyping. A high perceived value of studying ICT magnified the lowering effect of self-efficacy in ICT on gender stereotyping.

3.2.4. Hypothesis 4

A mediation analysis was performed to investigate the effect of perceived value of studying ICT on the relationship between perceived difficulties in using ICT and ICT-related gender stereotyping. The outcome variable for the analysis was ICT-related gender stereotyping. The predictor variable for the analysis was perceived difficulties in using ICT. The mediator variable was perceived value of studying ICT. First, the regression of perceived difficulties in using ICT on ICT-related gender stereotyping was significant without considering the effect of the mediator, $b = 0.19$, $t(396) = 2.76$, $p = 0.006$. Second, perceived difficulties in using ICT was a significant predictor of the mediator, perceived value of studying ICT, $b = -0.20$, $t(396) = -5.61$, $p < 0.001$. Third, perceived value of studying ICT, when controlling for perceived difficulties in using ICT, was significant, $b = -0.23$, $t(395) = -2.39$, $p < 0.018$. Fourth, perceived difficulties in using ICT on ICT-related gender stereotyping, when controlling for perceived value of studying ICT, was also significant, $b = 0.14$, $t(395) = 2.02$, $p = 0.044$. The final step showed that the indirect effect of perceived difficulties in using ICT on

Table 3
Hierarchical multiple regression analysis on the prediction of ICT-related gender stereotyping.

		b	*SE b*	β
Step 1				
	Constant	5.25	0.54	
	Self-efficacy	−0.18	0.07	−0.14*
	Perceived value	−0.20	0.10	−0.10
Step 2				
	Constant	1.03	1.70	
	Self-efficacy	0.82	0.39	0.63
	Perceived value	0.55	0.30	0.29
	Interaction	−0.18	0.07	−1.01**

Note. $R^2 = 0.04$ for step 1; $\Delta R^2 = 0.02$ for step 2 (*ps* < 0.05). *p < 0.05, **p < 0.01, ***p < 0.001.

Table 4
Moderation effect of predictors on ICT-related gender stereotype.

	β	*SE B*	*T*	*P*
Constant	3.36 [3.2176, 3.5047]	0.07	46.04	<0.001
Self-efficacy in ICT (centred)	−0.18 [-0.3408, −0.0232]	0.08	−2.25	0.025
Perceived value in studying ICT (centred)	−0.24 [-0.4631, −0.0153]	0.11	−2.10	0.036
Self-efficacy in ICT × Perceived value in studying ICT	−0.17 [-0.3194. −0.0298]	0.07	−2.37	0.018

Note. $R^2 = 0.0588$.

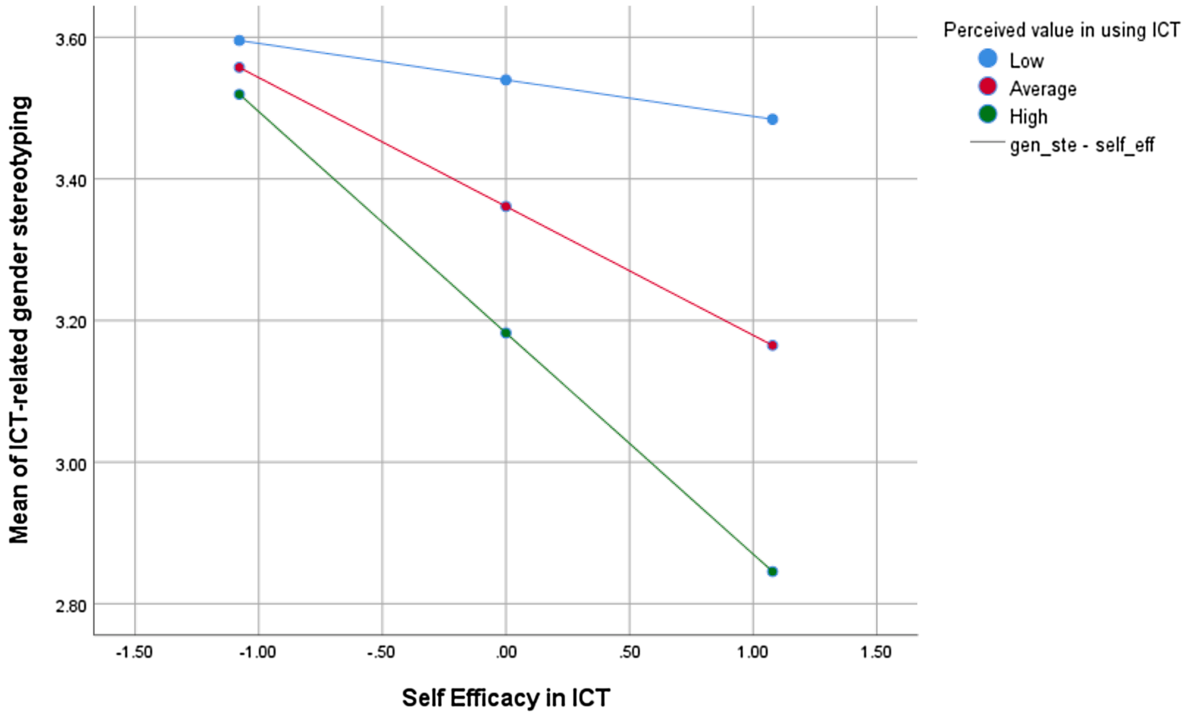

Fig. 4. The effect of self-efficacy in ICT on ICT-related gender stereotype at three levels of perceived value in using ICT.

ICT-related gender stereotyping was also statistically significant (b = 0.045, 95% C. I. (0.005, 0.087)) (see Fig. 5).

3.3. *The overall effectiveness of the program*

To conclude the overall impact of the ICT training on the variables examined in the present study, paired sample t-tests were computed to compare the mean scores of each variable from pre-test (T_0) to post-test (T_1). As shown in Table 5, students' problem-solving skills, analytical ability, self-efficacy in ICT, and interest in studying ICT significantly increased after attending the training sessions. Moreover, their perceived difficulties in using ICT and ICT-related gender stereotyping significantly decreased. Although perceived value of studying ICT also increased after the training sessions, the improvement was statistically insignificant.

Table 5
Mean score difference of variables between pre & post test.

	Pre-test (T_0)		Post-test (T_1)			
	M	SD	M	SD	t	p
Problem-Solving Skills	4.66	0.90	4.83	0.97	−3.86***	<0.001
Analytical Ability	4.82	1.05	5.03	1.06	−3.90***	<0.001
Self-efficacy in ICT	4.51	1.08	4.84	1.08	−7.31***	<0.001
Perceived Difficulties in Using ICT	3.41	1.04	3.23	1.20	3.36***	<0.001
Interest in Studying ICT	4.95	0.94	5.08	0.98	−3.08**	0.002
Perceived Value in Studying ICT	5.76	0.75	5.80	0.88	−1.10	0.273
ICT related Gender Stereotyping	3.29	1.42	3.10	1.56	3.08**	0.002

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

4. Discussion and conclusion

Based on the findings, the association among the measured variables can be outlined and provide theoretical support for designing a STEM education program (see Fig. 6). First and foremost, the regression results relating students' problem-solving skills and analytical ability with their ICT self-efficacy and perceived difficulties in using ICT provide support for using an inquiry-based model of teaching and learning in STEM education. As demonstrated in the program of the present study, the students were assigned with a project to work on. Making use of micro: bit coding skills, they were required to think and act to find solutions and produce wearable items with different LED light patterns and perform catwalks in the mini fashion show. These processes demand that students analyze and find appropriate responses to the problem; as a result, their problem-solving skills and analytical ability will be

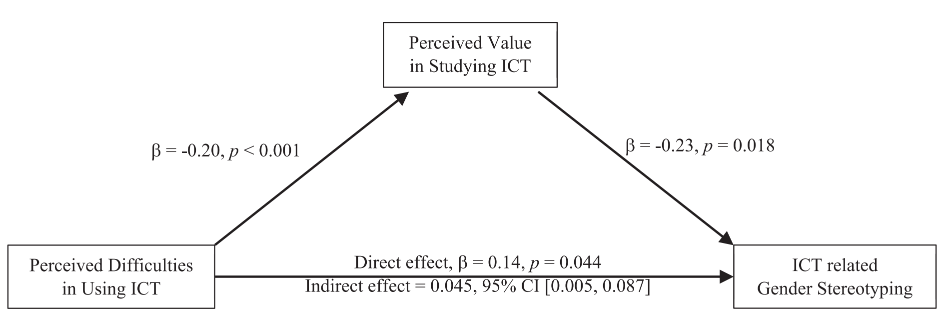

Fig. 5. Mediation effect of predictors on ICT related gender stereotype.

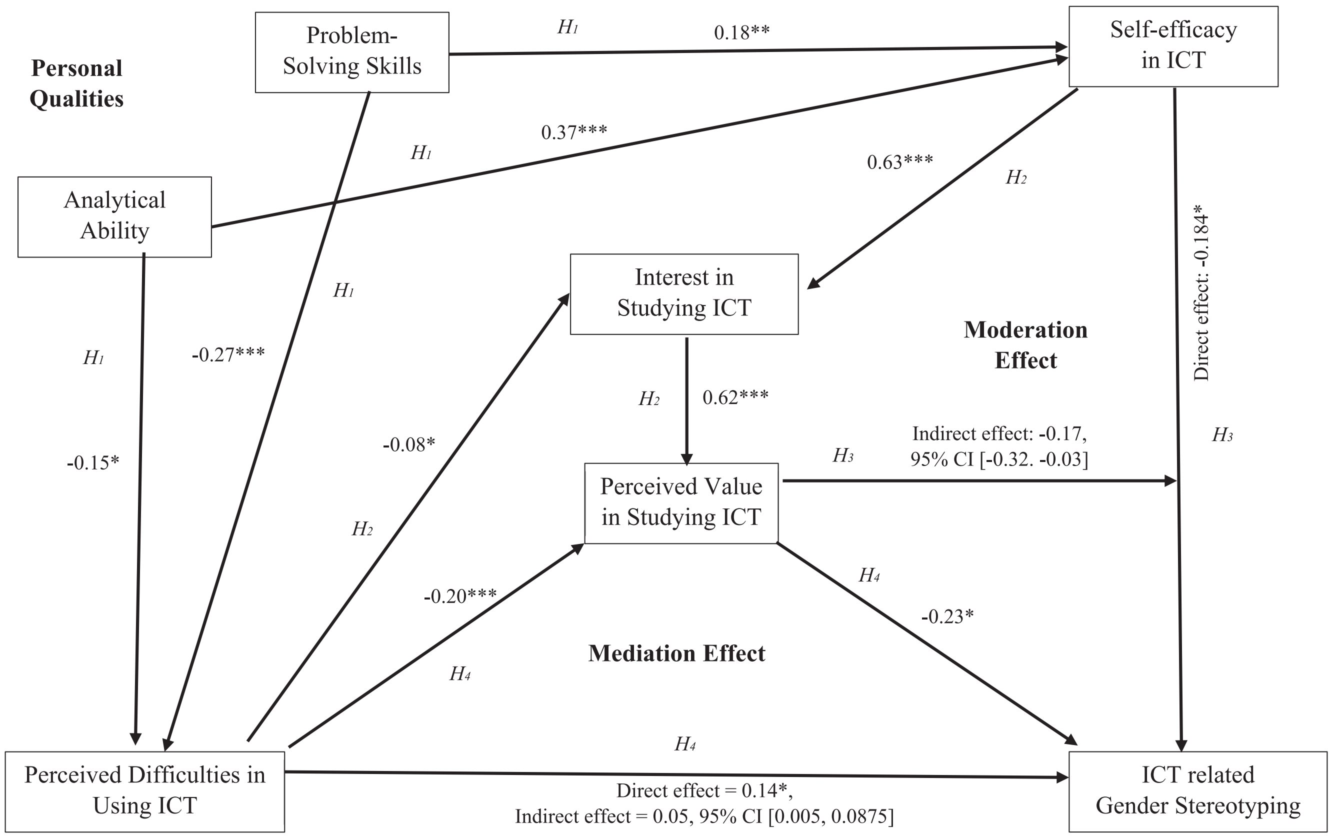

Fig. 6. Regression diagram of ICT gender stereotyping of Junior Secondary School Female Students in Hong Kong.

developed. Because the findings revealed that high problem-solving skills and analytical ability predicted high ICT self-efficacy and low perceived difficulties in using ICT, an inquiry-based model is an effective approach to hone both problem-solving skills and analytical ability, leading to a significant improvement in students' self-efficacy in ICT and a reduction in perceived difficulties in using ICT. It is recommended that an inquiry-based model should be adopted in more STEM education programs to promote students' problem-solving and analytical abilities, in return, contribute to their ICT self-efficacy.

4.1. *Role of female students' perceived value of studying ICT*

The results also indicated strong ties among self-efficacy in ICT, perceived difficulties in using ICT, ICT-related gender stereotyping, and perceived value of studying ICT. Students' perceived ICT-related gender stereotyping decreased with increased self-efficacy in ICT and decreased perceived difficulties in using ICT. Further, the perceived value of studying ICT was a critical factor influencing these effects, by moderating the effect of self-efficacy in ICT and mediating the effect of perceived difficulties in using ICT on ICT-related gender stereotyping. These findings underline the significance of perceived value in determining the perception of gender stereotyping among student participants. On one hand, the perceived value of studying ICT is a moderator, with an enhancing effect, on the relationship when students with high perceived value of studying ICT and self-efficacy in ICT would have the lowest level of perceived ICT-related gender stereotyping. It means that when female students believe ICT as important to their learning and future career, regardless of gender, they tend to be more motivated to learn and perceive ICT as a less masculine activity. On the other hand, perceived value is also a mediator between the effect of perceived difficulties in using ICT and ICT-related gender stereotyping. Students with fewer difficulties in managing ICT are more likely to enjoy the benefits of technologies. The positive experience they gained from using ICT leads to a stronger perceived value of studying ICT. When students view ICT as equally significant to both girls and boys, the ICT-related gender stereotyping should be reduced.

Meanwhile, the present findings also revealed that self-efficacy in ICT and perceived difficulties in using ICT were strong predicting factors of student interest in studying ICT, which further predicted their perceived value of studying ICT. Because self-efficacy is influential to what people think and how they feel, people with higher self-efficacy tend to be more positive when facing challenges and more interested in a specific subject (Bandura, 2010). Thus, the results showed that individuals with higher self-efficacy in ICT were more likely to find ICT interesting, which is consistent with findings from previous studies on ICT self-efficacy and interest (Bozdogan & Özen, 2014; Silvia, 2003). People with a high interest in studying ICT tend to be motivated to continuously participate in ICT learning. The more ICT knowledge and skills they learn, the more positive experiences they gain from manipulating ICT in their life. As a result, they perceive that ICT has a higher value in their life, which leads to a greater intention to study ICT and develop a career in the ICT industry (Gorbacheva et al., 2014; Miliszewska & Sztendur, 2010). In sum, the perceived value of studying ICT is a significant factor in the relationships between self-efficacy in ICT, perceived difficulties in using ICT, and ICT-related gender stereotyping. More emphasis should be placed on promoting students' perceived value of using ICT in creating STEM education program in order to maximize its effectiveness in tackling gender stereotyping in ICT education and industry.

4.2. *Effectiveness of an inquiry-based STEM education model*

Not only does the present study demonstrate how ICT training promotes students' self-efficacy in managing sciences and technologies, but also it provides empirical evidence on the effectiveness of a STEM education program in enhancing student development and gender equality in ICT. These findings are particularly important to places where STEM education is in the early stage and ICT-related gender stereotyping is still apparent such as in Hong Kong. The findings of the present study demonstrated that an inquiry-based ICT training workshop was mostly effective. Six out of seven measured variables, except for perceived value of studying ICT, were improved immediately after the three-day intensive ICT training workshop. Adopting an inquiry-based model in the training, students were encouraged to apply their skills and knowledge into practice by creating wearable items with micro:bit controlled LED light patterns for a mini fashion walk, which allowed students to develop problem-solving skills and analytical ability. Moreover, the ICT training session provided an invaluable experience for students to improve their ICT skills and enjoy playing with the technologies, which led to a rise in their self-efficacy in ICT and interest in studying ICT. They also found that more exposure to ICT technologies made ICT less difficult. However, the improvement in perceived value of using ICT was not statistically significant. This finding is the basis of a recommendation to improve the effectiveness of STEM programs, which is discussed in the next subsection. Based on the results, it is recommended that more STEM programs should be launched and promoted in places where STEM education is still in the early stage, particularly those using an inquiry-based model, to maintain the ICT competitiveness of students.

4.3. Empowering girls through effective STEM training

In addition, the findings indicate that STEM education can be an effective means to empower girls, in return, contribute to the equality in the ICT industry. According to Van Eerdewijk et al. (2017), empowerment is both an outcome and a process in which women and girls get more control over their lives. In the individual level, empowerment is a sense of self-efficacy occurred when people, they are girls in this study, who belong to a stigmatized social category are assisted to develop and increase skills, knowledge and resources to master their environment and self-determination (Rubin & Rubin, 1992; Solomon, 1976). It is a bottom-up and internal transformation from a state of helplessness to a state of self-efficacy, self-worth, and self-esteem. Through ICT training to secondary school girls, perceived ICT-related gender stereotyping among the participants was reduced. Because gender stereotyping in ICT gives a perception that ICT activities are more appropriate for men, ICT participation of women is often discouraged, further solidifying gender inequality in the industry. Nevertheless, this ICT training workshop granted an opportunity for female students to explore ICT and understand their potential in managing ICT technologies. Results showed that the students were more confident and interested in ICT after attending the workshop. Having acquired more ICT knowledge and skills, they are more likely to believe in women's capacity to manage ICT. Their ICT-related gender stereotyping significantly decreased after the workshop. Thus, the results suggest that an effective ICT training program allows the female student participants to experience an enhancement of ICT self-efficacy and a reduction in gender stereotyping, paving a path for them to take continuous participation in ICT and further join the industry.

4.4. Concluding remarks

As noted above, the perceived value of studying ICT played important mediation and moderation roles in the entire relationship framework, despite its statistically insignificant improvement after the training. One of the possible factors for the outcome is the duration of the workshop. The three-day training workshop in this study covered knowledge about micro:bit, Apps coding, and video making. Given time limitations, the workshop tended to be practical and intensive. Although students were allowed to work on a project and solve problems together, their cognitive level did not change significantly. Moreover, the applicability of micro:bit, Apps coding, and video making was also bounded in the preparation for the fashion walk; thus, students might not have perceived a major change in the value of using and studying ICT in their own life. Extending the duration and expanding the scale of the ICT training workshop are possible ways to produce a more significant impact on students' perceived value. The introduction of a greater diversity of activities, such as visiting ICT companies, interviewing IT giants, and joining in different IT competitions, into the STEM program could be useful in promoting student all-around development, including perceived value.

In Hong Kong, the Government had announced its support for STEM education both in the primary and secondary schools since 2015. However, similar with the program conducted in the present study, majority of the STEM and ICT training programs are still organized as short-term and extracurricular activities in the collaboration with NGOs or ICT training companies. Due to tight teaching hours, only few schools arrange STEM programs in regular lessons or even in curriculum-based with cross-disciplinary classroom teaching. (Hong Kong Federation of Education Workers, 2017; Leung, 2020). In this situation, immediate effects of the training might be influenced. To further enhance the positive outcomes of STEM education particularly for students' perceived values in managing ICT, it is worth considering longer-term and curriculum-based training for students. Of course, some studies argued that time and formal curriculum requirements inherent in traditional learning environments often limit STEM activities' efficient implementation (Baran, et al., 2019). Out of classroom activities, such as field trips, summer camps, and science fairs, which provide flexible and effective learning contexts might not be possible in curriculum-based design. In recent years, blended learning or flipped classroom design for STEM education becomes more common integrating in-class and out-of-class, in-school and at-home, online and offline teaching and learning activities (Fung, 2020). To guarantee students' marketability and competitiveness in technology-led contemporary societies, more studies should be carried out to test the effectiveness of STEM programs with different formats and content of delivery so that continuous modification can be made.

5. Limitations

Limitations of the current study stem from the sample, self-report nature of the survey, and measures. Because the workshop in this study is a training program aimed at girl capacity in ICT education, only girls from 13 partnered secondary schools in Hong Kong were recruited for the study. The sampling was not random; participating students and schools voluntarily joined the study based on interest. As a result, representativeness is limited due to the sampling method used. Moreover, because the sample was limited to girls in Grades 7 and 8, the findings may not be generalized to students in other education levels or to boys. Their claims for future study or career choice in STEM and ICT should also be taken cautiously. Future studies on STEM education in Hong Kong should use samples with boys and girls at different education levels to expand the representativeness and generalizability of the results.

Furthermore, this study used a self-reported survey in which the measures of variables were quite subjective and based on participants' individual judgment. Social desirability bias may have led to more positive ratings after the workshop. In future studies, more objective assessments could be implemented to measure the variables, particularly for problem-solving skills and analytical ability.

Finally, all measured variables were relatively novel and without extensive support from the existing literature. As all measuring scales were newly developed through a pilot study, more research should be conducted in this field to create a database of valid and reliable scales for studies reviewing the effectiveness of STEM education.

CRediT authorship contribution statement

Hau-lin Tam: Conceptualization, Funding acquisition,

Methodology, Investigation, Formal analysis, Writing - original draft. **Angus Yuk-fung Chan:** Writing - original draft. **Oscar Long-hin Lai:** Writing - original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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