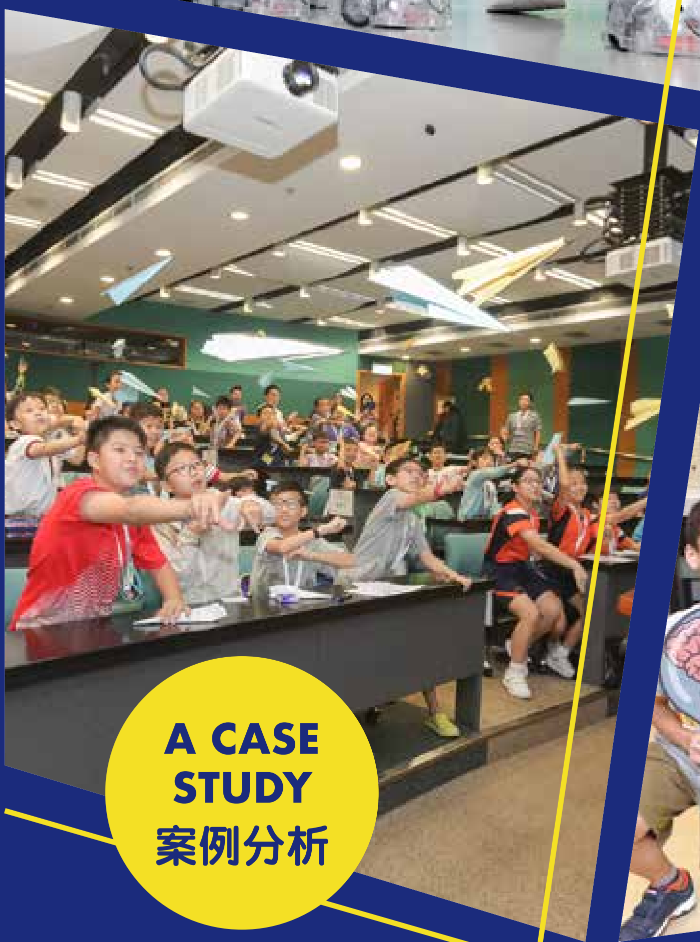
COOLTHINK@JC
賽馬會運算思維教育

SPURRING CHANGE IN HONG KONG CLASSROOMS
促進香港課堂系統革新



A CASE STUDY
案例分析

EXECUTIVE SUMMARY
摘 要

With the rapid approach of the "4th Industrial Revolution", which will see robotics and artificial intelligence start to take over many of today's routine tasks, educators and policymakers worldwide are looking at ways to reshape their education systems so that the coming generations will be better equipped to face the challenges of the 21st century – not just more technologically savvy, but also more creative, more innovative and more competent in problem-solving skills. There is often a gap, however, between broader curriculum reform and achieving real change at classroom level, especially in a results-oriented educational environment like Hong Kong.

It is in this context that The Hong Kong Jockey Club Charities Trust (the Trust) decided in early 2016 to take a proactive approach by funding a four-year, HK$216 million pilot project, CoolThink@JC, to introduce computational thinking (CT) into a broad sample of schools citywide at upper primary level and thus provide a body of evidence and experience to stimulate longer-term discussion and reform. CT education uses computer coding principles to encourage children to learn from an early age how to address challenges in a systematic and logical way.

From the outset, the Trust recognised that to make CT education workable and successful, a number of barriers would need to be overcome, as resources were already stretched in many schools and the idea of teaching young children computer coding might seem alien and unnecessary. The project would need to be strategically sound, politically supportable and organisationally feasible, as well as capable of standing on its own feet once well established, allowing the Trust to step aside. Above all, the gap would need to be bridged between existing CT education methods and tools, mostly developed overseas, and putting them into practice at classroom level in Hong Kong.

One of the Trust's unique strengths in this respect is its ability to convene and orchestrate collaborative partnerships with sometimes disparate third parties – and not only fund large projects, but also play a hands-on role in guiding and implementing them. In this case, the Trust brought together a group of experienced local and international partners as co-creators: The Education University of Hong Kong, Massachusetts Institute of Technology (MIT) in the USA, and City University of Hong Kong. A Steering Committee involving both public and private sector members was also set up to seek advice and support from other interested stakeholders.

The CoolThink@JC pilot project was introduced in 32 local primary schools of different types citywide from 2016/17 academic year onwards and has been supported by extensive teacher professional development initiatives, workshops and parent education activities. A standard set of learning materials has been developed for pupils in Primary 4 to 6 grades, and the schools involved have been given support where necessary in adding the relevant hardware and infrastructure.

Among the notable findings to date, more than 90% of school principals citywide have expressed their support for coding education and would like to see it strengthened; 80% of teachers trained under the project have found they teach CoolThink in a different, more student-centric way; and 76% say they would recommend it to others. Perhaps most importantly of all, 89% of the student projects have demonstrated innovative capability, while CoolThink students have shown significant growth in problem-solving skills compared with students not participating in the project.

While it may be too early to celebrate success, the Trust believes that the lessons it has learned as not only a funder of the project, but also a proactive steward of it, can provide policymakers, community leaders and other philanthropists with some useful insights on how to design and manage a project of this ambition and scale. This Case Study of CoolThink@JC is therefore intended to share the Trust's learning from the initiative.

全球將迎來「第四次工業革命」，預計機械人技術及人工智能會逐漸取代眾多日常業務，為確保新一代能準備就緒，應對二十一世紀的挑戰，讓他們善用科技之餘，更會發揮創意、敢於創新及具備解難能力，世界各地的教育家和決策者正努力尋求方法，改革教育制度。不過課程改革跟課堂實際成效往往存在差距，特別是在香港這個以成績掛帥的教育環境之下 。

有見及此，香港賽馬會慈善信託基金（信託基金）於 2016 年初主動策劃並捐助二億一千六百萬港元，推行為期四年的先導項目「賽馬會運算思維教育」計劃 (CoolThink@JC)。在全港多間小學的高年級引入運算思維（computational thinking, 簡稱 CT），以實證及經驗，拋磚引玉，帶動長期討論及革新。計劃利用電腦編程教授運算思維，培養兒童從小學習按部就班，以邏輯思維應付挑戰。

從構思計劃之初，信託基金已意識到必須克服多重障礙，方可成功推行運算思維教育，畢竟不少學校的學習資源有限，提出在高小級別教授電腦編程似乎不切實際。因此，項目需要具備完善策略，並與政策互相配合，務求在校內可切實推行之餘，亦有能力在計劃成熟發展後持續自行運作。更重要的是，教授運算思維的方法和工具大多由海外機構研發，引入香港前需要先填補文化差距，才可在課堂上付諸應用。

香港賽馬會慈善信託基金透過創造跨界別平台，連繫不同背景的合作夥伴，制定解決方案及展開創新服務計劃，共同回應社會需要。信託基金夥拍本港及國際多所經驗豐富的機構，包括香港教育大學、美國麻省理工學院及香港城市大學，聯合策動「賽馬會運算思維教育」計劃；同時亦邀請來自公私營機構的人士加入督導委員會，向各界徵詢意見及尋求支持。

「賽馬會運算思維教育」計劃自 2016/17 學年開始在本港 32 間不同類型的小學推行，並輔以全面的教師專業發展計劃、工作坊及家長教育活動。目前 CoolThink@JC 已為小四至小六的學生編訂完善的教材，並為有需要的聯網學校提供支援，以添置相關硬件和基礎設施。

計劃推行至今，全港超過九成小學校長表示支持編程教育，明言希望加強這方面的工作；八成曾接受「賽馬會運算思維教育」計劃培訓的教師表示會用更以學生為本的方式教授運算思維；其中七成六教師表示會向他人推薦本計劃。更重要的是，八成九的學生專題習作展現出創新能力；而且對比未參加計劃的學生，曾接受運算思維教育的學生解難能力明顯提高。

先導計劃成果初現，信託基金希望藉著本案例分析，分享在策劃及捐助計劃所汲取的經驗，以供決策當局、各界領袖和其他慈善機構參考，作為日後設計及管理性質和規模相近的計劃之用。

THE NEED FOR NEW THINKING

亟待注入新思維

In recent years, the Trust has put a particular focus on four areas of strategic importance to the city's long-term sustainable development – Youth, the Elderly, Sports and Arts, Culture & Heritage. The Trust's youth policy is aimed at preparing the city's young generation for the challenges ahead of them in a rapidly-changing world, and developing a positive outlook on life. In this regard, both the Trust and other community stakeholders have been concerned for some years that Hong Kong's current education system, while fundamentally strong and successful, needs to adapt more swiftly to the changing needs of the 21st century. It is producing students who may be very academically qualified, but do not necessarily have the essential skills and mindset required for success in today's more competitive workplace, such as creativity, critical thinking and social competence. According to a 2015 global survey of employers, educators and students by the Economist Intelligence Unit, 'problem solving' is ranked as the most in-demand skill today.

It has therefore become an important mission of the Trust's youth strategy to help instigate change in the city's educational offerings – and in its research and discussions with experts and academics worldwide, the topics of computational thinking (CT) and coding education have continuously resurfaced. It was from these roots that the project now known as CoolThink@JC (**Co**mputati**o**nal**Think**ing) started taking shape.

Making good use of its ability to fund large-scale projects and bring together local and overseas partners who could contribute the necessary expertise, the Trust decided to initiate and fund a sufficiently broad pilot study to provide a body of evidence that CT education at upper primary level (Primary 4 to 6) in Hong Kong could be both achievable and beneficial to students. The four-year pilot covered 32 schools spanning different socio-economic backgrounds, academic achievement records and experience in early computing education. It is hoped that the results, including lessons learned from the pilot, could also provide policymakers, community leaders, educators and other grant-makers with wider insights on how to introduce new teaching approaches in Hong Kong, and thereby stimulate longer-term discussion on curriculum reform.

近年，信託基金策略性地重點推動四大範疇慈善項目，包括青年、長者、體育及藝文，以促進社會長遠持續發展。當中啟發青年的策略旨在協助本港新一代做好準備，應對未來瞬息萬變的挑戰，並樹立積極的人生觀。信託基金和其他持份者一直關心香港行之有效的教育制度能否更迅捷地應對二十一世紀不斷變化的需求。我們培養的學生除了學術成績優異，更須具備創造力、明辨性思考及社交能力等各種技能和思維，方可在現今競爭劇烈的職場中綻放光芒。根據 2015 年《經濟學人》智庫（Economist Intelligence Unit）對全球僱主、教育工作者和學生的調查，「解難能力」是現時需求最殷切的技能。

協助革新本港教育課程因此成為信託基金青少年策略的重要一環。經過信託基金與全球專家和學者的持續研究及討論，逐漸確立運算思維和編程在教育課程的重要性，並為「賽馬會運算思維教育」計劃定下基礎。

信託基金更決定策動並捐助這項大型先導計劃，除了捐助資金，更召集本地及海外合作夥伴，一同在香港小學高年級（小四至小六）推動實證為本的運算思維教育課程。為期四年的先導項目涵蓋社會經濟背景、電腦學科成績及經驗各不相同的 32 間學校。信託基金希望透過分享研究成果及先導計劃的經驗，能為決策當局、社區領袖、教育界人士和其他慈善團體就如何在香港引入新教學法提供參考，並藉此帶動課程革新的討論。

FROM PLANNING TO REALITY : OVERCOMING BARRIERS

從規劃到實踐：克服障礙

It quickly became clear from exploratory discussions with educators and policymakers that many barriers would need to be overcome, both practical and perceptional, to bring the aspiration of early CT education in Hong Kong to reality. The Trust was determined to address the challenges that arose and come up with a pilot scheme that would be strategically sound, organisationally feasible and systematic supportable, as well as sustainable in the longer term.

It is no secret that making changes in classroom teaching is always more difficult than adding extracurricular programmes either after school or out of school. Especially at primary level, curricula, textbooks and teaching approaches are well embedded. While new or experimental approaches might be possible in a few select schools, systemic change could only be achieved if demonstrated on a sufficiently large scale. It was therefore necessary for the CoolThink@JC pilot to involve a broad and extensive sample of primary schools, covering different social strata and communities citywide. This would also reinforce the important message that CT is a skill both needed and attainable by all, not just elite students.

Another significant barrier in this case was that relatively few primary school teachers come from a computing background; Information & Communications Technology (ICT) is not considered a mainstream subject at primary level, so will rarely be taught by specialists. Moreover, the teaching of coding requires a very hands-on, practical approach, working with individual students to help them choose and create projects, rather than teaching from textbooks. This meant that CoolThink@JC needed to encompass a comprehensive professional development programme for the teachers involved, which would give them the practical support and hands-on experience they needed to get started.

Further challenges were the issues of infrastructure and resources. Although many schools already provide students with access to computers and wi-fi connections, and some even have separate computer rooms, traditional classroom designs are still focused on equipment, while CT is aimed at inspiring digital creativity; the schools would need to be offered help to upgrade. In addition, many teachers in Hong Kong are tied up with classroom duties, paper marking, after-school classes, communications with parents and an increasing volume of administrative work. Proactive efforts would be needed to avoid exacerbating their workload.

Last and certainly not least, it was necessary to build support and buy-in from school management, who might be concerned about investing class time in a subject that did not count towards grades; and from parents, who might worry that their children were already spending too much time in front of computer screens.

經過與教育工作者和決策當局深入研究和討論後，大家都了解到要克服許多障礙才能實現運算思維教育願景。故此，信託基金提出一項不論在策略和組織上都極具意義及可行的先導計劃，以應對在香港推行早期運算思維教育可能面對的種種障礙，並推動長期持續發展。

眾所周知，改變課堂教學遠比增設課外或校外活動困難，尤其是在課程、教科書和教學方法環環緊扣的小學階段。儘管被選定的學校願意採用嶄新或實驗性質的教學方法，但只有在大規模的推行才能改變現有的系統。因此，「賽馬會運算思維教育」計劃必需廣泛進行，涵蓋各小學及覆蓋社會不同階層，同時需要加強傳遞一個重要訊息：運算思維不僅是精英學生獨有的，而是一項所有人都必學的技能。

計劃中的其中一個困難，是擁有電腦學科背景出身的小學教師相對較少，資訊及通訊科技在小學階段亦不屬主流學科，因此很少專科老師教授。此外，編程教學是一門講求實踐的學科，老師需要與個別學生交流，協助他們選擇和創建項目，而不是單單從教科書中進行教學。這意味著 CoolThink@JC 需要為參與教學的教師提供全面的專業發展計劃，為他們提供入門所需的實際支援及實踐經驗。

另一個挑戰是基礎設施和資源問題，儘管許多學校已經為學生提供了電腦和無綫上網，甚至設置獨立電腦室，可是傳統課室設計仍側重於設備，而運算思維則旨在激發數碼創意，學校需要提升裝備，以更好地教授運算思維。此外，本港教師大多忙於課堂工作、批改習作、補課班、與學生家長溝通，以及要處理越加繁重的行政工作。因此，計劃的設計必須竭力避免加重他們的工作量。

最後的重要一環，計劃需要得到學校管理層和家長的支持及參與，畢竟要投入課時於不計入成績的科目，使用電腦學習亦容易被誤會過度沉迷電腦，會令校方及家長有所顧慮。

SOUND STRATEGY: COMPUTATIONAL THINKING OVER CODING

完善策略：運算思維不止於編程

Although IT education has been part of school curricula in most developed countries for more than 40 years, traditional teaching methods are more geared to helping students make practical use of technology rather than be the creators of it. Increasingly, however, governments and educationalists around the world are recognising that rapid social changes are calling for a more forward-thinking approach, as part of wider curriculum reform to better prepare students for the challenges of the 21st century.

One of the project focus is coding – the creation of the instructions on which all website operations, smartphone apps and other computerised devices in the home or workplace rely. In the coming decades, those who are merely users of technology will be the ones whose jobs are most at risk when robotics and artificial intelligence take over many routine tasks. On the other hand, those who can create technology will be the new builders and architects of the digital age.

Coding requires not so much technical knowledge as the ability to analyse a task in a logical way and break down the steps necessary to achieve it. Those who learn coding will therefore learn far more than just writing computer programmes; they will become more creative, more innovative and more skilled in problem-solving in all aspects of everyday life. In other words, they will develop what has become known as Computational Thinking, or CT. To give an analogy, acquiring CT involves far more than learning coding, just as appreciating music involves more than learning to play the piano, and understanding astronomy goes beyond learning how to use a telescope.

Studies around the world have shown that much younger children are able to learn and understand simple coding principles – and develop stronger creative and thinking skills as a result. Estonia (the birthplace of Skype and often cited as one of the world's technological leaders) has been teaching coding to pupils as young as six since the 1990s, as has Israel, another technologically-advanced society.

Within Asia, the Singapore government launched a nationwide Code@SG initiative in 2014 to promote coding in schools. South Korea has made computing a required elementary school course since 2017, and Japan plans to make it a compulsory subject at primary level from 2020.

In Hong Kong, the Government's Digital 21 Strategy unveiled in 2014 recommended "Programming in every child's education" as an action item. In late 2017, not long after the start of the CoolThink@JC pilot, the Education Bureau published the "Computational Thinking: Coding Education - Supplement to the Primary Curriculum" (2017) and recommended that coding be introduced into the curriculum at the upper primary level to develop students' computational thinking. The Technology Education Curriculum was also updated, schools need to allocate at least 30% of the lesson time of the Information and Communication Technology (ICT) knowledge context at junior secondary level to teach programming.

儘管大多數發達國家，資訊科技教育已被納入學校課程達 40 多年，但傳統教學方法仍傾向協助學生學習操作科技，而非創造科技。然而，世界各地政府和教育工作者皆意識到要面對社會的急速變化，必須在廣泛的課程改革中使用更具前瞻性的方法，讓學生有更好準備，應對二十一世紀的種種挑戰。

CoolThink@JC 的其中一個教學重點是編程，即編寫電腦指令。電腦指令是所有網站運作、智能手機應用程式及家庭或工作間電腦設備的基礎。在未來數十年，當機械人和人工智能逐漸取代許多日常工作之時，那些只懂使用科技的工作崗位會變得岌岌可危。相反，懂得創造科技的人將成為數碼時代的建築師。

編程其實不需要太多的技術知識，而是需要邏輯分析能力，可以逐一拆解步驟，完成任務。因此，學懂「運算思維」的人不僅是學懂編寫電腦程式；更可以在日常生活中變得更具創意、勇於創新，及具備更強的解難能力。作個比喻，學習運算思維遠不止於學習編程，就像欣賞音樂遠不止於學習彈鋼琴，理解天文學也不止於學習使用望遠鏡一樣。

世界各地的研究顯示，學童愈早學習和理解簡單的編程原理，愈有助發展更強的創造力和思考能力。Skype 發源地愛沙尼亞及經常被稱為世界科技領袖之一的以色列，自 1990 年代起，便已向年僅六歲的小學生教授編程知識。

在亞洲，新加坡政府已於 2014 年向學校推廣編程教學，並在全國推行 Code@SG 編程運動。南韓政府自 2017 年起，已將電腦運算列作全國小學必修科；而日本則計劃於 2020 年把運算編程列為小學必修科。

香港政府於 2014 年推出「數碼 21 資訊科技策略」計劃，建議把程式設計納入兒童基礎教育範圍。在 2017 年底，即「賽馬會運算思維教育」計劃先導項目啟動後不久，教育局公布《計算思維：編程教育 - 小學課程補充文件》(2017) 建議在高小課程中引入編程，以培養學生的運算思維。教育局亦更新了科技教育學習領域課程，當中學校需在初中「資訊及通訊科技」的知識範圍中撥出不少於 30% 的課時教授程式編寫。

FEASIBLE ORGANISATION: DESIGNING THE PROJECT

切 實 可 行 的 項 目 設 計

In planning the CoolThink@JC initiative, the Trust was able to benefit considerably from the wide body of research conducted overseas in recent years. A number of useful programmes and teaching tools were also available overseas, albeit with limited evidence to show which strategies worked best. It was clear, however, that to meet the project's goals and address the unique needs of the Hong Kong market, the Trust would need to work closely with both local partners and overseas experts to develop – largely from scratch – a curriculum that was suitably geared to local students and teaching practices, along with the necessary textbooks and reference materials.

The Trust therefore engaged The Education University of Hong Kong (EdUHK) and Massachusetts Institute of Technology (MIT) in the USA to create the CT Framework for CoolThink@JC. MIT has been supporting coding education since the 1950s and developed a number of easy-to-learn coding applications, while EdUHK trains the majority of the city's primary school teachers. Combining the expertise of both institutes, a CT Framework has been developed which covers the three main modules of Concepts (learning the fundamental principles of coding), Practices (applying these skills to problem-solving) and Perspectives (learning to create and express one's own ideas in the same way). Besides a solid CT framework and curriculum, MIT and EdUHK also developed training and professional development programme to enhance teacher capabilities and experience in this area.

In addition, the Trust decided to fund the assignment of two teaching assistants to participating schools to support each CoolThink class. These assistants are current or graduate students trained by another project partner, City University of Hong Kong (CityU), which has a strong track record in STEM (Science, Technology, Engineering and Mathematics) education. Depending on the needs of the teacher and the class, these assistants can play a variety of roles, ranging from troubleshooting the students, managing their different learning pace, and occasional instructional support for teachers who were not yet confident about teaching the CT lessons.

To support the pilot schools' hardware and infrastructure needs, the Trust's funding also includes grants to upgrade their existing computer and wi-fi systems, including up to 32 new notebooks, tablets and asssociated equipment each. More importantly, funding of HK$100,000 per school is offered to create a dedicated "CoolThink@JC Studio" with different design and equipment from traditional computer rooms. This studio can serve as a "billboard" to communicate the school's commitment to CT across the whole teacher and student bodies, as well as sending a strong signal of the Trust's commitment to the project.

在籌劃「賽馬會運算思維教育」計劃時，信託基金廣泛參考了近年海外研究的計劃設計和教學工具。儘管未有證據顯示哪一種策略最湊效，卻明顯地說明要達到計劃目標並滿足香港市場的獨特需求，信託基金需要與本地合作夥伴和海外專家緊密合作，由零開始制定適合本地學生的課程和教學實踐，以及提供教師所需要的教科書和參考資料。

因此，信託基金委託香港教育大學（教育大學）及美國麻省理工學院（麻省理工）為「賽馬會運算思維教育」計劃創建了課程框架。自 1950 年代以來，美國麻省理工學院一直致力於編程教育，開發了許多易於學習的編程應用程式，而教育大學則精於教師培訓，多年來培育了本港大部份小學教師。兩間院校的團隊糅合其專業知識，為計劃開發運算思維教育框架，當中涵蓋「概念」（學習編程的基本原理），「實踐」（運用技巧解決問題）和「視野」（學習以同樣方法創建和表達自己的想法）。除了紮實的運算思維課程框架外，麻省理工和教育大學還制定了培訓和專業發展計劃，以提升教師在此領域的能力和經驗。

此外，計劃亦為每間參與學校的編程課堂提供兩名助教。被派遣的助教均是現屆大學生或畢業生，並由另一個項目合作夥伴、在 STEM（科學，科技，工程和數學）方面一向成績斐然的香港城市大學（城市大學）進行培訓。根據老師和課堂的需求，這些助教可以協助學生排解疑難，跟進學生不同的學習進度，以及支援對教授運算思維課程尚未得心應手的老師，在課堂中擔當不同的角色。

為滿足先導學校的硬件及基礎設施需求，信託基金亦撥款資助學校提升電腦及無綫網絡系統，包括向每間學校提供多達 32 台全新的手提電腦、平板電腦及相關設備。更重要的是每所學校均獲得 100,000 港元的資金，用於建設一個與傳統電腦室截然不同的「賽馬會運算思維教育」創意天地。該創意天地猶如廣告牌般，向所有師生宣揚運算思維教育的理念，同時也強烈表達出信託基金對推行計劃的信心。

SUPPORTIVE SYSTEM: ENGAGING STAKEHOLDERS

連 繫 各 方

It was recognised at the very beginning by the Trust that the most critical factor of all in ensuring the success of CoolThink@JC and its long-term extendibility was winning support and buy-in from interested stakeholders, including Government, school principals, teachers and parents.

To support the engagement process, the Trust retained SRI International (SRI), a research institution originally established by Stanford University, to conduct an independent and rigorous, evaluation research both before and during the project. These findings would provide stakeholders with evidence-based justifications for introducing the project, as well as facilitate continuous refinement of the design based on early results, and in due course enable lessons learned to be shared with the global community.

The Government's Education Bureau was brought on board from the earliest stages, and consultations and focus groups arranged with educators, academics, parent associations and other interested parties to help in conceptualising the project and developing the curriculum. An extensive programme of seminars and workshops was also launched to explain to principals and teachers the thinking behind the project and how it would be implemented. These were well received and encouragingly, applications were received from more than 150 schools for the 32 available places in the pilot scheme.

A cross-sector Steering Committee has been set up to direct the progress of CoolThink@JC, its members including the Permanent Secretary for Education, representatives of the co-creators EdUHK, MIT and CityU, the Hong Kong Aided Primary School Heads Association and two individuals with appropriate knowledge and expertise.

信託基金一早便意識到，要確保「賽馬會運算思維教育」計劃取得成功及長遠發展，最關鍵因素是獲得政府、學校校長、教師和家長等持份者的支持和參與。為支持政策順利進行，信託基金委託史丹福大學的研究機構——國際史丹福研究所 (SRI)，在項目開展前後和項目進行期間，進行獨立且嚴謹的評估研究。研究成果可為計劃提供實在的依據，同時有助參照早期成果，不斷改善設計，並在適當時與國際社會分享所得經驗。

計劃早於籌備初期已邀請教育局參與，聯同教育工作者、學者、家長協會及其他相關團體協助將項目概念化及發展課程。同時亦舉辦研討會及工作坊，向校長和教師解釋計劃的宗旨及實行方法。令人鼓舞的是，這些安排廣受好評，先導計劃的 32 個名額亦獲得超過 150 間學校申請。

CoolThink@JC 團隊更成立了一個跨界別督導委員會以指導整個計劃的發展，委員會成員包括教育局常任秘書長、共同策劃機構——香港教育大學、美國麻省理工學院及香港城市大學的代表、香港資助小學校長會的代表，以及兩位具備相關知識的專業人士。

ENCOURAGING ACHIEVEMENT
成果卓著

Working closely with the project co-creators, EdUHK, MIT and CityU,
the CoolThink@JC pilot has made a significant impact on primary school technology education.

有賴共同策劃機構：教育大學、麻省理工及城市大學的緊密協作，「賽馬會運算思維教育」計劃為小學科技教育帶來正面影響。

Curriculum Development

Together, the EdUHK and MIT teams developed a three-year curriculum for upper primary student covering fourteen class hours over each academic year, with a final project for each grade level to integrate the year's learning with practical applications. MIT's visual programming tools are used as the main teaching tool, being well proven and designed to match the knowledge levels of younger children – as well as being readily accessible beyond the classroom. The lesson content itself is interactive and encourages collaboration, balancing both learning and practical activities.

課程發展

教育大學與麻省理工團隊攜手合作，共同為小學高年級學生編制為期三年，每學年十四個課時的課程，另為每年級安排年終習作，務求學生能學以致用。CoolThink@JC 使用麻省理工的視覺化程式作為主要教學工具。此程式經過充份驗證，適合學童的知識水平，亦可於課後隨時使用，配合互動的課堂內容及學生協作，務求在學習和實踐之間取得平衡。

24

curriculum units developed, piloted and enhanced
設計、試驗及增強 24 個單元課程

32

Network Schools supported
支援 32 間聯網學校

21,000

More than 21,000 students have benefited
惠及超過 21,000 名學生

112

teachers trained
名教師完成培訓

78

Each teacher received 78 training hours
每位教師接受 78 小時培訓

Teacher Professional Development

To address the limitations on teacher capabilities and experience in this area, professional development covering two certificate courses of 39 hours each was offered to teachers from the 32 pilot schools – the first course delivered by MIT on coding and computation thinking knowledge and project-based learning, the second by EdUHK on teaching methods and co-curricular activities.

教師專業發展

為解決教師在電腦科技領域能力和經驗的局限，計劃安排 32 間先導學校的教師修讀兩個專業發展證書課程，每個課程 39 小時。第一個課程由麻省理工提供，涵蓋編程、運算思維知識，以及專題研習；第二個課程由教育大學提供，教授教學方法及聯課活動。

Classroom Support

Given the collaborative hands-on nature of the classes, teaching assistants trained by CityU becomes a valued assets for teachers. They play an important role in CoolThink class by assisting the troubleshooting and managing students' different learning pace. These teaching assistants are to some extent "ambassadors" of the CoolThink@JC project. They have reached out to thousands of students supporting their CoolThink experience first-hand in the classroom. It is hoped they can also continue contributing to their schools' further development of the subject beyond the pilot period.

課堂支援

由於課程屬協作及實踐性質，由城市大學培訓出來的教學助理成為教師的寶貴資產。教學助理可協助學生排解疑難、管理學生不同的學習進度，已支援超過一萬名 CoolThink 課堂的學生，在計劃中扮演著重要的角色，嚴然計劃的大使。 我們亦期望教學助理在計劃結束後，能夠繼續為學校相關學科的發展作出貢獻。

28,875

co-teaching hours supported
支援 28,875 個小時運算思維課堂

1,250

teaching assistants trained
1,250 名教學助理完成培訓

18

teacher leaders raised
培育 18 位教師領袖

35

InnoCommunity Schools supported
支援 35 間創新社群學校

Teacher Peer Support

A community of practice, InnoCommunity, was formed by passionate teacher leaders to support and equip schools that are interested in adopting CT education, and catalysing classroom-level change. Besides providing short courses, the teacher leaders have acted as coaches to support peer reviews with the InnoCommunity schools. At the Education Bureau's invitation, professional development programmes have been co-organised for primary school teachers in the 2020/21 school year, so as to familiarise them with the project's pedagogy and education resources.

教師同行支持

一群充滿熱誠的教師領袖組織了「創新社群」實踐群組 ，支援有興趣採用「賽馬會運算思維教育」計劃課程的學校，促進課堂革新。除提供短期課程外，資深教師還擔任導師，支援其他學校的教學評估。應教育局的邀請，創新社群更於 2020/21 學年協辦小學教師專業發展課程，幫助教師熟悉 CoolThink 的教學法及教學資源。

Infrastructure Support

Encouragingly, all pilot schools set up CoolThink@JC studio on campus. These facilities, equipped with programmable hardware devices for teachers and students to tinker with, helped raise awareness of the project within school and inspire students and parents beyond the classroom. An all-in-one electronic learning platform was also developed to support teaching, resources management, data collection and reporting.

基礎設施支援

令人鼓舞的是，所有先導學校均在校園內設立「賽馬會運算思維教育」創意天地，添置編程設備供師生實習操作。設施不單提高全校對運算思維的認識，並啟發學生和家長在課堂以外的興趣。項目亦開發了一個綜合電子教學平台，以支援教學、資源管理、收集數據及匯報結果。

32

schools have had their computer rooms revamped
已有 32 間學校改造校內的電腦室

2,800,000

Course materials on the electronic learning platform have been viewed or downloaded 2,800,000 times since launch
自推出以來，電子教學平台上的教材瀏覽或下載達 2,800,000 次

Community Education

Community education is one of the main focus areas of the project, aimed at soliciting support from different stakeholders. Various activities, including family workshops, seminars, competitions, summer camps and coding fairs have been organised to educate parents and other stakeholders on the importance of CT education and equip them with the necessary knowledge and skills for helping their children's development of computation thinking.

CoolThink@JC is driving and leading computational thinking discussion and collaboration globally. Its two principal investigators have been invited to give keynote presentations at more than 10 international events, whilst its annual conferences have attracted educators and scholars from 20-plus countries, spurring the formation of an International Research Network under the World Educational Research Association.

社區教育

社區教育亦是計劃非常重視的其中一個環節，籍此爭取不同持份者的支持。計劃舉辦了各種活動：包括親子工作坊、研討會、比賽、夏令營及編程嘉年華等各項活動，循序漸進地教導家長及其他持份者了解運算思維的重要性，並為他們提供為子女建立運算思維所需的知識和技能。

計劃亦積極推動及引領全球的運算思維討論及合作，兩位主要研究人員獲邀出席超過 10 場國際活動及發表專題演講，而年度運算思維教育國際會議則吸引來自 20 多個國家的教育工作者和學者出席，並促使了世界教育研究協會（World Educational Research Association）成立了轄下的國際研究網絡（International Research Network）。

177 Family Workshops attended by **2,620** parents

177 個親子工作坊，出席家長達 2,620 人

2 Coding Fairs 個編程嘉年華

4 CoolThink@JC Summer Camps 個運算思維夏令營

4 Computational Thinking Competitions 個運算思維比賽

4 International Conferences on CT Education 個運算思維教育國際會議

Policy Support

With the Education Bureau's policy steering continuous learning and pathway connection in computational education, there is a growing importance of adopting computation thinking in classroom.

July 2020: EDB published the "Computational Thinking: Coding Education - Supplement to the Primary Curriculum" (2020), recommending schools to adopt the document in curriculum planning and implementing coding education systematically to cultivate students' computational thinking.

Jun 2020: EDB updated the "Information and Communication Technology Curriculum and Assessment Guide (S4-6) Supplementary Notes" for senior secondary education, adding the learning elements on Computational Thinking, Artificial Intelligence, and Ethic to DSE ICT elective.

政策支持

教育局現已制訂政策，指導運算思維教育的持續學習及銜接，令運算思維在課堂的重要性與日俱增。

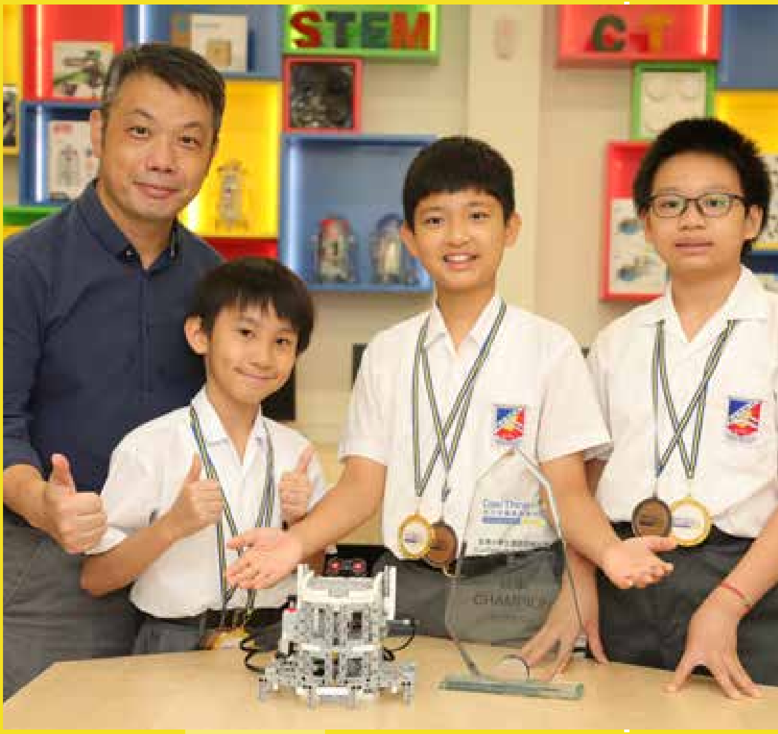
2020 年 7 月：教育局公佈最新的《計算思維：編程教育 - 小學課程補充文件》(2020) ，建議學校於課程規劃中採用該文件，有系統地推行編程教育來培養學生的運算思維。

2020 年 6 月：教育局修訂高中教育的《資訊及通訊科技課程及評估指引（中四至中六）課程補充資料》，在中學文憑考試「資訊及通訊科技」的選修科目中加入運算思維、人工智能及倫理的學習元素。

Independent Evaluation

The independent research conducted by SRI shows promising evidence on the project's outcomes and impact.

- **Pilot students exhibited stronger learning of CT Concepts than their peers in comparison schools.**
- **Pilot students achieved particularly strong results in logical reasoning and problem-solving.**
- **Both boys and girls benefited from CoolThink@JC instruction, while the relative gains in CT Concepts were stronger for boys than for girls.**
- **80% of the teachers reported adopting new teaching strategies in teaching CoolThink@JC, with a shift towards more student-centric approaches.**
- **Teachers' training by EdUHK and MIT played a substantial role in preparing teachers to teach CoolThink@JC, and supporting their perception of computation thinking.**
- **Most teachers found teaching assistants to be essential support, and was particular helpful early in implementation.**
- **Principals appreciated how CoolThink@JC catalysed teacher community and helped them to advance their schools towards STEM goals.**



獨立評估

SRI 進行的獨立研究顯示，計劃的成效和影響令人滿意。

- **參與學生比對其他學生，在運算思維概念方面展現出更強的學習表現。**
- **參與學生在邏輯推理及解決難題方面成績特別出眾。**
- **男女學生皆能受益於「賽馬會運算思維教育」計劃教學，而男生在運算思維概念方面相對得益較女生多。**
- **八成教師表示自己運用新教學方法教授運算思維，並更以學生為中心。**
- **教育大學及麻省理工提供的師資培訓能有效幫助教師理解運算思維，並為授課作好準備。**
- **大多數教師認為教學助理的支援不可或缺，在教學早期尤為重要。**
- **校長欣賞計劃有助促進教師互助，並引領學校達成科學、技術、工程和數學（STEM）的教學目標。**

Source: CoolThink@JC Pilot Evaluation (http://www.sri.com/case-studies/evaluation-of-coolthinkjc-a-computational-thinking-initiative-in-hong-kong-primary-schools/)
資料來源：「賽馬會運算思維教育」計劃先導項目評估 (http://www.sri.com/case-studies/evaluation-of-coolthinkjc-a-computational-thinking-initiative-in-hong-kong-primary-schools/)

A LEARNING EXPERIENCE FOR ALL
教學相長

Being a project specifically targeted at breaking new ground in Hong Kong education, the roll-out of CoolThink@JC has not been without its setbacks – it was never expected otherwise. An important aspect of the Trust's strategy was providing an opportunity for the pros, cons and logistics of CT education to be thoroughly aired and examined during the four-year pilot so that ultimately, a proven and well-supported curriculum could be readied for wider introduction across Hong Kong schools.

For example, the first round of teacher feedback indicated that the initial stage of the curriculum for Primary 4 students was proving somewhat over-ambitious, hence changes needed to be made that would allay these concerns without compromising the overall direction and quality of the project.

Generally, however, feedback has been highly encouraging. For example, many teachers have commented how much they have learnt themselves from the project, and reported that it has led them to take a much more collaborative approach to their teaching in general – both in terms of working more closely with their students on individual projects, and in sharing projects and experience with teachers at other schools. A common observation is that the project allows more opportunity for students to explore their own ideas in class and learn from trial and error – something they can rarely do in other subjects.

作為一個嘗試在香港教育領域尋求突破的項目，「賽馬會運算思維教育」計劃的推行並非一帆風順。四年先導計劃旨在讓運算思維教育的利弊和各項安排得以實行和驗證，最終制訂實證為本的課程，供全港學校使用。

例如，第一輪教師反映，小四課程推行初期略為過深，計劃於是在不影響項目的整體方向和質素的情況下，適度調整課程。

但是，整體而言，項目的成效令人鼓舞。例如許多教師表示因為參與此計劃而獲益良多，以及在整體教學方面能更以協作為重，不但與學生更緊密合作，還與其他教師分享經驗。教師普遍認為計劃讓學生有更多機會在課堂上探索自己的想法，從反覆試驗中學習，而這是在其他學科少有的機會。

The co-curricular activities, an integral part of the initiative, have proved popular and successful, with the annual citywide student competitions drawing entries from 487 teams involving over 1,450 students since 2017, and coding fairs attracting in excess of 9,000 participants in total.

Formative evaluation has shown that 89% of the Year 1 student projects have demonstrated innovative capability and nearly 70% of the students have either experimented with or created something novel or unique, with 8% extending that to creating something 'cutting edge'. It is also exciting to note that students who have received CT education under CoolThink@JC have been found to acquire twice the level of problem-solving skills as their peers who have not participated.

計劃中的課外活動，一直深受歡迎，成效甚佳。自 2017 年起每年舉辦的全港小學生運算思維比賽，合共吸引了 487 支參賽隊伍和 1,450 名學生參加，而編程嘉年華則有超過 9,000 人參與。

進度評估顯示，首年參與學生的專題習作有八成九具有創新能力，近七成學生曾嘗試創造新穎或獨特的作品，其中接近一成學生更創建尖端的作品。而令人興奮的是，參加過 CoolThink@JC 的學生的解難能力，其水平相較未曾參與過計劃的同學高出一倍。

"I always look forward to CoolThink lessons. I have much fun during class time. I get to work on my tasks and it's very satisfying when I can overcome the errors on my own." – P4 student

小四學生：「CoolThink 課堂總是讓我十分期待，課堂十分有趣，我可以自己完成任務。每當我自己成功為程式除錯便感到十分滿足。」

"More interactions and brainstorming are seen among the four CoolThink teachers. They are more actively working on the planning and preparation as it is more challenging curriculum than before. They also take more initiative in coming up with ideas or new ways to teach the lesson." – Principal

校長：「四位參加 CoolThink@JC 的教師較以往更多互動、更能激發創意。這個課程比以往更具挑戰性，因此他們更加積極規劃和備課，而且更主動思考新的教學意念或方法。」

"The lessons are led by students. There are lots of discussion opportunities for the students. Teachers only guide the students." – Teacher

教師：「課堂由學生帶領，他們有許多討論機會，而教師只是從旁引導。」

"After learning coding, he has become more independent in learning. He will try to find answers himself when he encounters a problem." – Parent

家長：「他 (兒子) 自從學習編程後，學習方面變得更獨立。遇到問題時，他會先嘗試自己找答案。」

Almost all of the 32 pilot schools have continued their CT education in the 2019/20 academic year and more than 90% say they will keep making use of the CoolThink@JC trained teachers and materials after the current phase of the project concludes in 2020, while others will await further policy and curriculum directions from the Education Bureau. At the time of preparing this case study, the Trust is delighted to see the Bureau has published "Computational Thinking: Coding Education - Supplement to the Primary Curriculum" (2020) recommending that all primary schools plan and implement coding education systematically to cultivate their students' computational thinking.

The project team has responded quickly during class suspensions resulting from the COVID-19 pandemic. In collaboration with co-creators and participating schools, CoolThink@JC has provided students, teachers and families with non-stop learning opportunities via an Online CoolThink Classroom and Family Online Workshops. Video lectures have enhanced students' learning in creativity, computational thinking and coding skills; the workshops have allowed parents to learn and practise with their children at home.

32 間先導學校幾乎全部在 2019/20 學年繼續推行運算思維教育，其中超過九成的學校表示先導計劃在 2020 年完結後，將繼續沿用接受過「賽馬會運算思維教育」計劃培訓的教師和相關教材，而其餘學校則等待教育局進一步發佈的政策和課程指引。在籌備本案例分析時，信托基金欣然得悉教育局已發佈《計算思維：編程教育 - 小學課程補充文件》(2020)，建議所有小學按部就班規劃及推行編程教育，以培養學生的運算思維。

在 2019 冠狀病毒疫情影響導致停課期間，計劃團隊亦迅速應對，透過與項目合作夥伴和參與學校合作，推出運算思維網上課堂及網上親子工作坊，為學生、教師和家庭提供無間斷的學習機會，持續提升學生創意、運算思維及編程技巧，亦讓家長有機會與子女在家一起學習和實踐運算思維。

TEACHER STORY 教師故事

Miss Cheng Yuen Ting is a Chinese language major who has been teaching her students Chinese language and music in St. Edward's Catholic Primary School. Staging a musical would have been a demanding but manageable assignment for her; however, asking her to teach students how to build an online game or create an app would have been inconceivable without professional development support – and equally importantly, without a mindset change on her part. She is among the 87% of teachers who now feel confident of implementing what they have learned in the CoolThink@JC Professional Development Programme to teach computational thinking.

At the Opening Ceremony of the CoolThink@JC International Conference on Computational Thinking Education 2019 cum Coding Fair, Miss Cheng even staged a rap performance to let her students share their CoolThink experience.

鄭婉婷老師主修中文，在聖愛德華天主教小學教授中文和音樂。籌備一場音樂劇對她來說是艱鉅但仍可勝任的任務。然而，指導學生製作網上遊戲或應用程式，如果缺少專業發展的支援和整個思維模式的改變，對她來説簡直難以想像。如今，鄭老師和其他八成七教師一樣，可以充滿信心地運用 CoolThink@JC 教師專業發展課程所學到的知識教授運算思維。

在運算思維教育國際會議 2019 暨編程嘉年華開幕儀式上，鄭老師更籌辦了一場饒舌表演，讓學生分享運算思維教育的體驗。

STUDENT STORY 學生故事

Chan Ho is a student from a CoolThink@JC network school, PLK Dr. Jimmy Wong Chi-Ho (Tin Sum Valley) Primary School. He used to be naughty at classroom and was a headache for the teachers. While he was attending the CoolThink class, his teacher realized that he was in fact eager for learning more. Within a minimal guidance from teacher, he completed a coding project on his own and outperformed all his classmates. Ho even went extra miles to navigate his way through the tough challenges and developed a sumo robot for competition. He has become more confident and acted as a student leader at CoolThink lessons to proactively assist his fellow classmates.

陳灝同學就讀的保良局王賜豪（田心谷）小學，是「賽馬會運算思維教育」計劃先導學校之一。從前他在課堂上很頑皮，讓老師們頭痛不已。當他上運算思維課時，老師卻觀察到他很積極學習，只要老師稍加指導，他就能獨力完成了一個編程習作，表現更超越了其他同學。陳同學甚至更進一步，克服各種艱難的挑戰，研製出一個相撲機械人參加比賽。現在他變得更有自信，亦成為了運算思維課堂上的學生領袖，經常主動幫助同學學習。

TEACHING ASSISTANT STORY 教學助理故事

Pang Yuke-yee has served as a Teaching Assistant in the project for two years. During her service as the teaching assistant, she realized her strong passion for education, and pursued education diploma on a part time basis. She is now a secondary school teacher and assisting school's technology development.

彭鈺儀在先導計劃期間曾擔任兩年教學助理。在協助老師教學期間，更喚醒了她對教育的熱情，驅使她以兼讀方式獲得教育文憑。現在她已成為中學老師，並協助學校的科技發展。

PLANNING THE WAY FORWARD
規 劃 未 來

With strong support from the education sector for continuing CoolThink@JC into a second phase once the current pilot ends in summer 2020, and many more schools having expressed interest in joining the project, the Trust has already endorsed moving CoolThink@JC into Phase II, with the aim of incorporating computational thinking into mainstream education.

隨著先導計劃於 2020 年夏季完結，有更多學校表示有興趣加入計劃。在教育界的大力支持下，信託基金已作出相應行動，隨即展開第二階段，希望將運算思維教育普及化。

Critical Mass of Adoption
擴大參與範圍

In the four-year Phase II period, CoolThink@JC plans to systematically extend its support to 200 primary schools, while widening its reach to non-participating schools via partner school sponsoring bodies, teacher associations and the Education Bureau. The plan in Phase II is to induce a change of practices in more than 70% of the public sector primary schools and direct subsidy scheme primary schools in Hong Kong, and move the needle on CT education.

在為期四年的第二階段，CoolThink@JC 擬按部就班將支援擴大至 200 間小學，同時透過與不同辦學團體、教師協會及教育局合作，拓展覆蓋範圍至非參與學校，鼓勵本港超過七成的公營小學和直接資助小學作出改變的第一步，共同推動運算思維教育的發展。

Sector Capacity Building
提升業界能力

Among school principals, 98% have suggested that more professional development opportunities should be provided to the teachers. This urgent need to develop teaching capabilities on a large scale could be a challenge to bringing CT education into the mainstream. Besides providing a more flexible professional development, Phase II will see experienced teachers transformed into mentor teachers, as well as pre-service teachers being trained to provide sufficient human capital to the sector.

九成八校長建議為教師提供更多專業發展機會，因為要普及運算思維教育，能大規模提升教師的教學能力至為迫切。除了提供更靈活的專業發展外，第二階段更會將有經驗的教師提升為導師，並為職前教師提供培訓，以求為教育界提供足夠的人力資源。

Public Awareness and Support
公眾認知及支持

Continuing the success of Phase I, more extensive parent education programme will be launched in Phase II to uplift the level of digital parenting in Hong Kong. The programme will equip parents with the necessary CT knowledge, skills and attitudes which are fundamental in guiding and parenting their children's CT development in the all-embracing digital world, as well as helping to induce their support towards implementation of CT education. Partnerships with like-minded organisations will also be sought in Phase II to amplify the impact of awareness-building events, with a focus on educating disadvantaged communities on the importance and benefits of CT education.

憑藉先導計劃的成功，第二階段將推動更廣泛的家長教育，為父母提供必要的運算思維知識，技能和建立正確態度，提升香港家長的數碼教養水平。在變化萬千的數碼世界中，這些項目對於引導和培養學童的運算思維發展至關重要，亦有助爭取父母對推廣運算思維教育的支持。計劃更會於第二階段物色具相同抱負的組織合作，提高公眾認知，並著重教育弱勢社群，向他們灌輸運算思維的重要性及裨益。

Upgrading of Enabling Tools
提升支援工具

Different schools need different types of teaching support, calling for a modular and school-based curriculum that enables them to adjust according to their readiness in terms of priorities and capabilities. It is the project's mission to offer CT education for all schools and narrow the digital divide in the society.

The project has also identified a need to invest in some pioneering research and development, such as adding the basic principles of artificial intelligence (AI), big data and robotics into the CT curriculum to help upper primary students make a smooth transition to junior secondary level.

不同學校需要不同類型的教學支援，計劃務求為學校提供有彈性的運算思維教育框架，讓學校可根據教程和能力發展校本課程，以填補社會的數碼差距。

計劃亦會投入資源，進行前瞻性的研究及發展，例如在運算思維課程加入人工智能、大數據及機械人技術的基本原理，以協助高年級小學生順利過渡初中階段。

Intellectual Leadership and Platform-Building
知識領袖及平台建設

Partner schools are encouraged to develop school-based CT teaching materials. In Phase II, closer collaboration will be sought among various stakeholders and experts to support both participating and non-participating schools. A licensing model will also be explored to facilitate the potential adoption and expansion of the CoolThink@JC model within and beyond Hong Kong.

計劃亦鼓勵參與學校發展校本運算思維教材。在第二階段，計劃將協調不同持份者及專家加強合作，為參與學校及非參與學校提供支援，亦會探索授權許可模式，以促進香港及其他地區採用及擴展 CoolThink@JC。

Since the project's inception in 2016, a broad consensus has emerged on the vital role that future-oriented skills play in helping students meet challenges they will face in work and society. The adoption, revision and reform of computer science, computational thinking and coding education is one of the most consistent and prominent thrusts in fostering future-oriented, 21st century skills.

The CoolThink@JC pilot scheme, with its broad implications in spurring systemic changes in Hong Kong classroom, has to be just the beginning. The Trust looks forward to scaling the initiative to a much wider, more diverse set of local primary schools; creating a self-sustaining ecosystem that nurtures digital creativity in all classrooms; working with policymakers and stakeholders to take CT education into the mainstream curriculum; and leading computational thinking innovation and development globally.

The Trust welcomes all existing and potential partners who share the same visions to come forward and discuss possible collaboration.

自計劃於 2016 年推出以來，社會各界已達成廣泛共識，協助學生建立各種未來技能以應付工作及社會的種種挑戰至為重要。要培養學生二十一世紀的前瞻技能，採納、修訂及革新計算機科學、運算思維及編程教育，無疑是其中一個最有效的途徑。

「賽馬會運算思維教育」計劃雖然只是一個開始，對促進香港課堂革新可謂意義深遠。信託基金期望將這計劃擴展至更廣泛、更多元的本地小學，並建立可持續發展的系統，在課堂內培養數碼創意，與決策者及持份者一起推動運算思維教育普及化，進而引領全球運算思維教育的創新與發展。

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