数码大趋势下，小朋友越来越早开始接触编程。（受访者提供）

与机对话更要与人对话

少儿学编程须把握平衡

报道⊙李雅歌
liyage@sph.com.sg
摄影⊙龙国雄
封面设计⊙黎巧缘
封面图片⊙iStock

数码时代，编程作为一种新兴语言正在悄悄走入人们的生活。如果说语言是人与人之间传递信息、交流情感的工具，编程语言（Programming Language）则是人与电脑交流的方式，通过计算机和人都能识别的语言发出指令、建构模型。

我国朝着智慧国的目标不断迈进，数码科技在各领域逐渐占据核心地位。在搭建智慧国愿景的过程中，各行各业如金融、医疗、物流、能源等都在经历数码化转型。编程作为构建数码平台的重要技能，一时间对于编程人才的需求大涨，坊间掀起了一股编程学习热潮。从少儿启蒙教育到中年转业计划，在全民编程热的背后有哪些考量因素？

10岁的李丞杰用编程建模预测疫情。

今年10岁的李丞杰两年前开始学习编程，如今已可以用Python（编程语言）写程式。疫情期间，李丞杰设计了一款监测模型，将输入型病例、疫苗接种率、住院率、康复率及死亡率等元素结合，可预测出不同情况下确诊病例的变化。父母经常在餐桌上讨论疫情新闻，一来二去李丞杰了解到各种变量之间的关系，就想到用编程建模，可以做出更加直观的预测。

妈妈Queenie介绍，儿子从小就很喜欢玩乐高编程机器人，两年前送他来学编程也是想要一试兴趣。“如今很多父母把编程纳入考量的兴趣选项之一，就像学艺术、音乐、体育等一样。这些年政府倡导科技发展的大方向，如果孩子刚好有编程的兴趣和天赋，何乐而不为。”

编程并非易事，是一系列逻辑关系链的组合，需要缜密的思考和计划。李丞杰说自己喜欢编程，也很享受解决问题的过程。他会用课余时间上网自学，看论坛找答案。遇到一时解决不了的问题，做点其他事分散注意力，等到灵感来了再回到电脑前尝试。兴趣爱好加天赋让他在短时间内进步迅速，目前已可执行17、18岁高中水平的编程项目。李丞杰长大后的梦想是想成为一名医生，用医疗知识结合编程技术研发纳米机器人，可在人工控制下进入患者体内查出病变位置并治疗。

Queenie观察孩子在学习编程后最大的进步，是养成了计算思维（computational thinking），可以运用逻辑归纳找到问题的最佳解决方法。在性格上更加沉稳，遇到问题时不慌乱、不放弃，而是经过思考一步步想办法。Queenie认为在未来，编程既是一种普遍使用的工具又是一门精专的技术，“可能大多数孩子不一定从事编程直接相关的行业，但培养出的编程思维，都可以运用到学习和生活中去。”

编程教育呈低龄化趋势

作为本地最早一批编程教育者，Loshberry创办人郑慧珊不仅做儿童教育，也当兼职讲师辅导成人培训课程。过去几年她注意到本地编程学校的数量大幅增长，推出的课程种类也越来越多，“早期本地仅有几家儿童教育中心，现在不少商场里都有编程学校。”家长也越来越了解编程教育的架构，早些年还须向他们解释何为编程，儿童为何要学习编程。如今他们多是有备而来，为孩子精挑细选适合的课程。

谈及家长的心态，郑慧珊认为，一部分家长是作为兴趣班或增益课程试试看，也有一部分是抱着长远心态，因为大学热门计算机科系的入学标准逐年提高，希望孩子从小接触打下扎实基础，将来比较容易考进相关专业。作为专业教育者，郑慧珊指

图像式编程通过拖拽动作搭建模型，为儿童学习提供了极大便利。

通过手工搭建模型培养儿童的系统性思维。（受访者提供）

出，编程作为一种逻辑分析能力，与孩子的思维成熟度和认知相关，并非越早开始越好，因人而异，毕竟每个人的理解力不同。除此之外，逻辑分析能力也需要在学校学习的过程中，通过数学、语言、科学等学科互相建立。

李丞杰所在的编程中心Coding Lab成立于2016年，联合创办人符永宁、王碴琍是一对夫妻档。作为父母，他们创办编程学校的初衷也是希望孩子能够从小接触编程。符永宁认为，“编程是属于数码时代的新语言（new literacy），希望孩子能够掌握这门语言，建立起计算思维。”过去几年伴随编程热潮，不但开办训练营的次数有所增加，孩子接触编程的年龄也越来越早，从原本9岁到7岁，到如今5岁就可以报名预备课程。还有“怕输”的父母，在孩子两岁时就已在等候名单中。

王碴琍介绍，根据孩子的启蒙程度，目前的课程安排主要分为几种：5-6岁儿童基础班，无须使用电脑，主要通过玩游戏或操控机器人等方式，养成习惯接受指令和发布准确指令。7-9岁通过Scratch等图像式编程工具做电脑游戏。10-12岁学习简单的手机应用（app）开发。到了13岁以后开始学习以Python为主的代码式编程（syntax coding），应试O、A水准的学业要求。

教育部说有更多学生对电脑应用计算（Computing）感兴趣，如今四年级至六年级的小学生在校参加“编码乐”（Code for Fun）增益课程。O水准电脑应用计算选修课程于2017年推出，如今提供这个科目的学校已从19所增加到23所，明年会进一步增加到30所。提供A水准电脑应用计算的学校也从2015年刚推出时的三所，增加到目前的11所。

图像式编程语言培养计算思维

儿童学习编程的年龄有逐年下降的趋势，也要归功于图像式编程（Block-based Programming）的普及，为少儿学习提供了极大便利。2003年，美国麻省理工学院和谷歌（Google）针对六岁以上孩童，联合研发了一款名为Scratch的趣味编程语言。使用者可以不认识英文单词，不会使用键盘，直接用鼠标拖动模块到程序编辑栏就可以编写故事书、动画片或者小游戏。图像式编程系统已经将基本指令的模块搭建好，孩子只须借助简单的拖拽动作建立框架、顺序或完成闭环即可，大大降低了学习难度。其作用是帮助孩子建立程序间的逻辑关系，从而培养独立解决问题的能力及计算思维。

采访过程中，计算思维是不断被提及的关键词。如果说学习编程的本质是培养计算思维，那么究竟什么是计算思维？2006年，卡内基·梅隆大学周以真教授在发表的论文“Computational Thinking”中首次系统定义了计算思维，即运用计算机科学的基础概念进行问题求解、系统设计，以及人类行为理解等涵盖计算机科学之广度的一系列思维活动。广泛来说它并非一个独立的学科，而是一种解决问题的思考方式，可以广泛应用在各个领域。谷歌将计算思维概括为四种类型：分解问题、模式认知、抽象思维、算法设计。

在符永宁看来，现实生活中如果具备计算思维有助于建立新系统，帮助简化步骤，解决问题。例如在生产运输链中可运用计算思维搭建自动化平台，让流程更加顺畅。有计算思维的人常在创新中寻找答案，通过搭建或完善系统来解决问题。

计算思维在今时今日如此受落，因为资讯爆炸时代大大增加了事物的复杂性，建立了更加广泛庞大的体系。面对未来全新的智能世界，人类需要全新的思维方式。从小培养儿童的计算编程思维，可以帮助他们建立系统性的思考体系，又能将问题层层剥离开来，应对事物的复杂性。

另一方面也有教育专家指出盲点，强调儿童学习要注意平衡，在生活中培养非逻辑思维同样重要。毕竟我们除了要与机器对话，更要与人对话，前者是为了利用机器解决某个问题，而后者才是人类生活本身及其所创造文明的本质。生活语言和人机语言这两种对话方式对逻辑有不同的要求，日常对话中理解语境要比语言的逻辑性更加重要。对处于认知及人格成长期的少年儿童来说，他们在成长过程中所接受的教育不应是片面的，在编程训练的同时，不能忽略生活中的实践逻辑。

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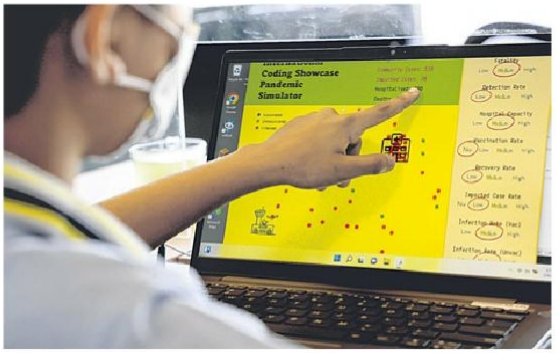
符永宁（右）和王碴琍创办编程学校Coding Lab的初衷是希望自己的孩子能够从小接触编程。



李丞杰设计了一款疫情监测模型，可预测出不同变量下确认病例的变化。

编程是属于数码时代的新语言（new literacy），希望孩子能够掌握这门语言，建立起计算思维。现实生活中如果具备计算思维有助于建立新系统，帮助简化步骤，解决问题。

——符永宁

Translation in English:

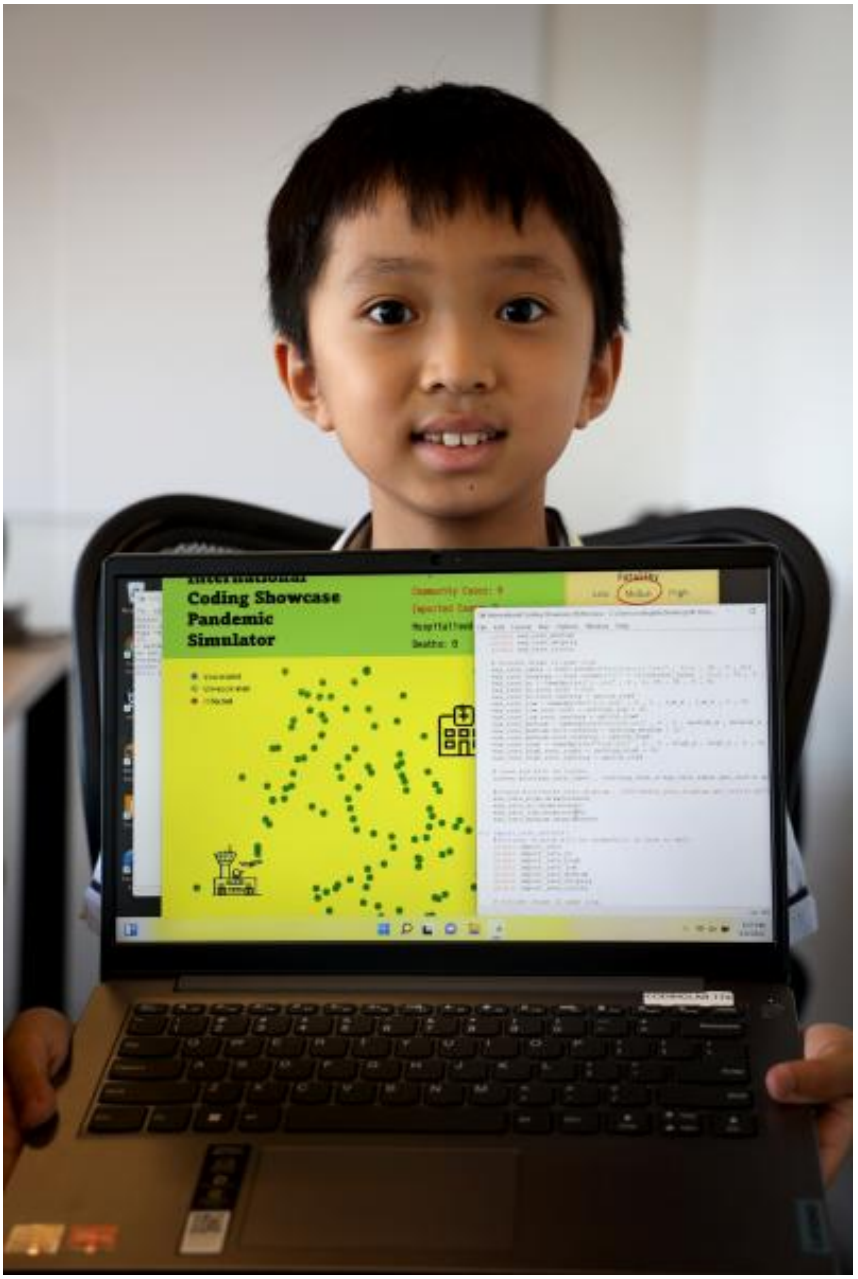
Learning Programming: Children Must Strike a Balance Between Communicating with Machines and People

Children learning to code should learn to maintain a balance between learning programming languages and human languages.

With the rise of the digital age, kids are coming into contact with coding at a younger and younger age.

Programming has been silently emerging as a new language in our lives in the digital age. If languages are a tool for humans to communicate thoughts and emotions with other people, programming languages are how humans communicate with computers, as we give instructions and construct models using a language that both computers and humans understand. In the advancement towards a Smart Nation, digital skills are slowly becoming the core of various sectors. Examples would be the finance, healthcare, logistics and energy sectors which are undergoing digitalisation. As programming becomes an important skill in building digital platforms, there is a sudden rise in demand for programming talents, setting off a craze in the learning of programming. What were the considerations in kids' programmes and mid-career conversion programmes in light of the craze in learning programming?

Theodore, 10, showed us his Covid-19 pandemic simulator which can predict the spread of the virus under different situations.



10-year-old Theodore programmed his own Covid-19 simulator.

10-year-old Chengjie Li (Theodore) started learning to code two years ago and is now able to code using Python (a programming language). During the pandemic, he designed a simulator that combines different elements like the number of imported cases, vaccination rate, hospitalisation rate, recovery rate, and fatality rate, to predict the changes in the number of confirmed Covid-19 cases in different situations. His parents often discussed news about the pandemic during meals, and after a while, Theodore understood the relationships between the different variables and thought about using programming modelling to value-add to the predictions.

His mother, Queenie, described Theodore to be someone who loves playing with Lego robots since young, and they sent him for coding classes two years ago to

further his interest. “Today, many parents consider coding as one of the potential areas of development, just like art, music, and sports. If my child has an interest and talent in coding, why not let him develop it, since the Singapore government has spent years advocating for digitalisation.”

Coding is not something easy. It involves a combination of logical thinking and connections which requires careful thinking and planning. Theodore says that he loves coding, and enjoys the process of problem-solving. He will use his spare time to self-study online and search for answers on forums. When faced with problems he could not solve immediately, he will do other things to distract himself first, and when inspiration hits, he will go back to try again. His passion and talent allowed him to progress fast in a short period of time, and he can currently execute high-level coding projects meant for 17-18 years old. His ambition is to become a doctor who uses medical knowledge combined with programming skills to invent a nanorobot which can enter the patients’ bodies to detect the disease location and carry out treatments.

Queenie observed that the biggest improvement in her child after picking up coding was the development of computational thinking, which is the ability to logically solve problems in the best way. His personality has become calmer, and when met with problems, he does not panic or give up, and will instead think through the problem step-by-step for a solution. Queenie sees programming as a common tool yet a specialised skill in the future. “Maybe most kids will not work in jobs directly related to programming, but the computational thinking skills developed can be used in their studies and daily lives.”

A trend towards coding education for younger and younger kids

As one of the earliest batches of coding educators, the founder of Loshberry Huishan Zheng not only engages in educating children but also works part-time as a lecturer in a class for adults. In the past few years, she noticed that the number of coding schools and types of classes has substantially increased. “In the earlier days, there were only a few kids coding centres, but now there are coding schools in quite a few malls.”. Parents now better understand the structure of coding education, as compared to the past when we had to explain to parents what coding was about and why children should learn to code. Today, they come well-prepared and ready to carefully select suitable classes for their kids.

Talking about the parents’ attitude, she feels that some parents treat coding classes as interest-development classes, while some have long-term goals for their children. These parents hope to build up their child’s foundation in coding as the cut-off point for the popular Computer Science course in university rises continuously over the years, so that they could get into related courses with ease in the future. As a

professional educator, she pointed out that programming is a logical reasoning ability which is related to the child's maturity in thinking and cognitive abilities, which differs in every child since they have different comprehension abilities, so it might not be that it will be better to start young. Other than this, when in school, the learning of mathematics, languages, and science also builds on their logical reasoning skills.

Coding Lab, in which Theodore attends coding lessons, was founded in 2016 by Yong Ning Foo and Candice Wang. As a married couple and parents, they originally established a coding school in hopes that their children could learn coding from young.

Yong Ning (right) and Candice originally established a coding school in hopes that their children could learn coding from young.

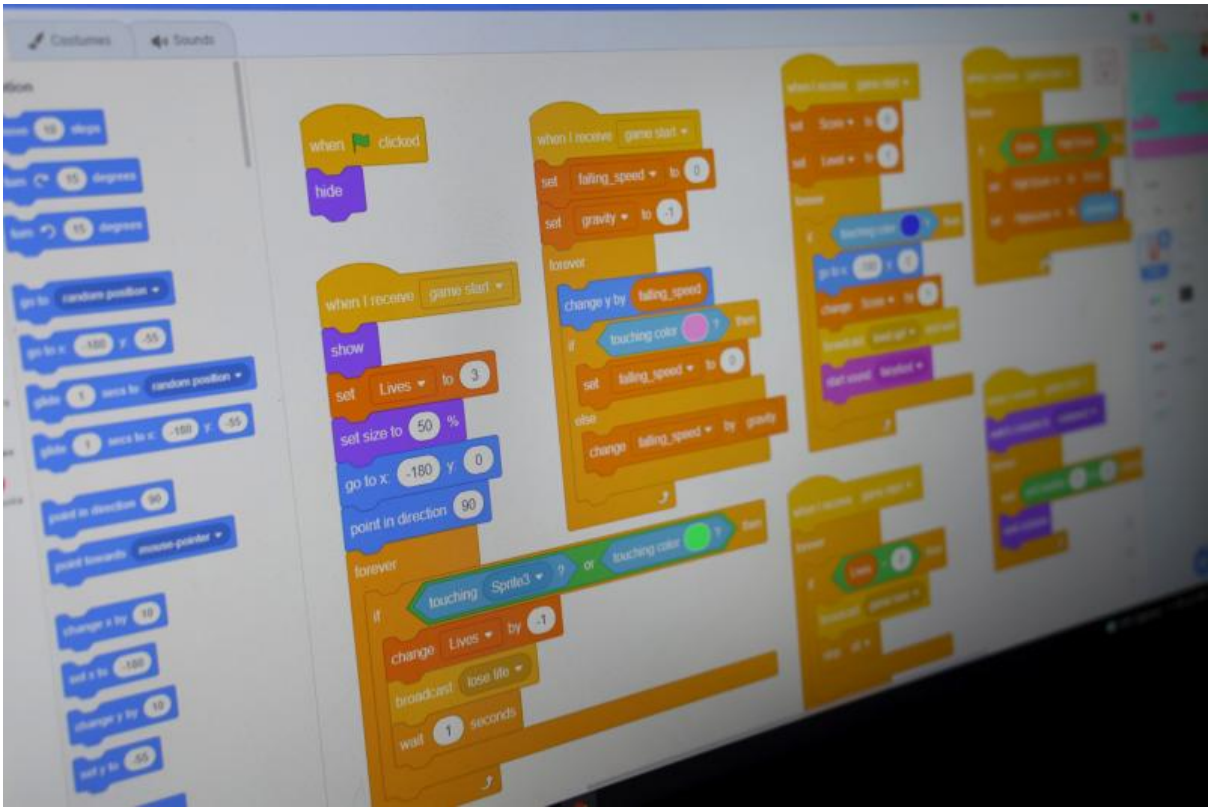
Yong Ning says that "Coding is a new literacy in the digital age. I hope that my children can grasp this language and build up their computational thinking skills." Following the rise in coding, Coding Lab has been offering more coding boot camps, and the ages of students attending the coding classes also became lower, from nine years old originally to seven years old, and today, five years old can register for the beginners' preparatory classes. Some "kiasu" parents have even registered their two-year-olds to be on the waiting list.

According to Co-Founder Candice, based on the students' learning abilities, the lessons are divided into a few categories currently. There is the 5-6 years old beginners' class, which does not involve the use of computers. Learning mainly takes place through playing games and learning to command a robot, in order to get used to taking in instructions and giving precise instructions. 7-9 years old learn using visual programming tools like Scratch to code their own games. 10-12 years old learn about basic app development. When they reach 13 years old, they start learning syntax coding with Python as the main language, in line with the GCE 'O' and 'A' level requirements.

The Ministry of Education states that more students are interested in Computing. Currently, Primary four to six students attend "Code For Fun" enrichment classes in schools. Computing was introduced in 2017 as an elective subject for the GCE 'O' levels. Today, the number of schools offering this subject has increased from 19 schools to 23 schools, and next year, it will be further increased to 30 schools. The number of schools offering 'A' level Computing has also increased from three in 2015 when it was first introduced, to 11 schools currently.

Using block-based programming to cultivate computational thinking

The trend of the younger age of the students learning to code can also be attributed to the convenience brought about by the popularity of block-based programming. In 2003, the Massachusetts Institute of Technology and Google collaborated to develop an interesting programming language called Scratch. Users need not understand English, or know how to type on the keyboard, and can simply use the cursor to drag the blocks to the coding area to code their own stories, animations, or games. Block-based programming uses a system where the basic commands are already set, and the children will only need to drag those blocks to build the framework, sequence them, or close the loops, lowering the learning curve. One of the intentions is to help the kids build their logical thinking skills, and develop their problem-solving skills and computational thinking abilities.



Block-based programming uses a drag-and-drop method, providing immense convenience for kids to learn.

During the interviews, computational thinking is a keyword that was constantly brought up. If the essence of learning coding is to develop computational thinking, what exactly is computational thinking? In 2006, Progressor Zhou Yizhen of Carnegie Mellon University was the first to systematically defined computational thinking in a paper “Computational Thinking”. She defines it as a series of thinking activities, including problem-solving, system-designing and human behaviour understanding etc., with the basic concepts of computer science. It is not an individual discipline, but a way of thinking to solve problems, and can be used in various fields. Google categorises computational thinking into four sections: decomposition, pattern recognition, abstraction, and algorithms.

Yong Ning sees computational thinking as something that will help to build new systems, simplify steps, and solve problems in our daily lives. For instance, in the production chain, computational thinking can help to build an automated system, improving the flow. People with computational thinking abilities often find answers in innovation and solve problems through building or utilising a comprehensive system.

Computational thinking skills are on a decline today due to the era of information explosion, which has created a more complex and wider system of things. Faced

with a new digitalised future, humans need a brand new way of thinking. Developing their computational thinking abilities from young can help children to build a systematic way of thinking, and can decompose complex problems layer by layer into simple steps to solve them.

Developing systematic thinking through the hands-on building of models.

On the other hand, educational experts have pointed out a blind spot, that there must be a balance in the kids' learning, and that developing non-logical thinking skills is as important. After all, other than talking to robots, we must also talk to humans. We talk to robots to make use of machines to solve problems, and we talk to humans as it is the nature of humans and civilisation itself. Languages in our daily lives and programming languages have different requirements. Understanding the context of our daily communication is more important than understanding the logic behind languages. For children in the process of developing their cognitive abilities and personality, their education should not be one-sided. In the learning of coding, they should not neglect the practical logic in their lives.

"Coding is a new literacy in the digital age. I hope that my children can grasp this language and build up their computational thinking skills. The computational thinking ability will help to build new systems, simplify processes and solve problems in our daily lives." - Yong Ning Foo