Scaling Up CoolThink@JC

Implementation Study Midline Report

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EXECUTIVE SUMMARY

Launched in 2016 and led by The Hong Kong Jockey Club Charities Trust (The Trust), CoolThink@JC is scaling the study of computational thinking to primary 4–6 students across the territory. By early 2023, the CoolThink network had enrolled 204 schools in six cohorts, achieving a critical mass of schools that will have adopted the 14-hour curriculum by the end of the scaling period. Moving forward, the CoolThink team is pursuing a two-pronged mission: supporting the continued success of the 200-plus schools within its network and promoting a successful rollout of computational thinking education (CTE) to all remaining Hong Kong primary schools.

This second report from SRI International's ongoing study of CoolThink implementation at scale examines the progress made by the CoolThink@JC initiative at midline. Based on a variety of data sources, it describes CoolThink implementation at the classroom and school levels in 47 Cohort 3 schools after two years of CoolThink adoption and in 52 Cohort 4 schools after one year. In addition, the report describes the development of an emerging ecosystem that can support CoolThink@JC at scale in Hong Kong, and factors that we expect to be important to a successful adoption by the full breadth of primary schools in the territory.

CoolThink classrooms at scale

The adoption of CoolThink@JC in classrooms is a complex undertaking, and by design the curriculum includes flexibility for teachers to adapt as they see fit for their students. As the curriculum scales, it is important to ensure that core design principles that shape the student experience in CoolThink classes remain intact.

Based on multiple data sources, students continue to experience CoolThink instruction that reflects the program's active learning pedagogy as it scales to more schools. Most network schools have been able to allocate the full recommended time for CoolThink@JC in their school schedules, despite COVID-related schedule restrictions that continued into the 2021-22 school year. Perhaps more importantly, students engaged in active learning consistent with the CoolThink pedagogy of "to play, to think, to code, to reflect" more often than in ICT classes taught prior to CoolThink@JC. Many CoolThink classes included a variety of CoolThink-aligned activities, combining coding and listening to the teacher with activities such as independent student exploration and problem solving.

As observed in the CoolThink@JC pilot, these more exploratory and conceptual activities are sometimes reduced in focus as teachers adapt the lessons to improve accessibility for their students or to fit into available instructional time. Some CoolThink teachers as well as mentor teachers have observed that in this adaptation process, supporting the successful completion of a task can take precedence over spending time to build students' conceptual understanding: an outcome that can be elusive for CoolThink students. But in general, student engagement—particularly in play, coding, and opportunities to be creative—remains high at scale, and the vast majority of teachers believe that CoolThink@JC has benefitted their students in multiple ways.

Equitable access to high-quality CoolThink instruction

Equity of educational opportunity for all students in Hong Kong is of primary importance to The Hong Kong Jockey Club Charities Trust. CoolThink@JC is taught as part of the regular school day, ensuring that computational thinking education is available to primary grade students in all circumstances. In addition, it is important to ensure that all students have a chance to engage in the same high-quality educational experience in their CoolThink classes, with similar opportunities for problem-solving and CoolThink-aligned pedagogies.

Students' experiences with CoolThink instruction differed depending on financial need, as measured by school-level financial aid rates. Although these differences were consistent across many measures of CoolThink implementation, most were not large or statistically significant. It is important to keep in mind that conditions for learning and pedagogical practices have often found to differ in higher-need schools in ways that may affect all classes, not solely CoolThink@JC. In this research, CoolThink teachers reported that CoolThink@JC may be more challenging for students in high-need schools in comparison with students in schools with low rates of financial aid, along with related pedagogical differences: students in higher-need schools spend somewhat more time listening to lectures and somewhat less time coding. Teachers also reported a range of improved CoolThink outcomes for students in lower-need schools, with some differences at or approaching statistical significance. It remains to be seen whether these differences in CoolThink implementation are related to differences in student outcomes, as measured by assessment of computational thinking concepts and practices. Although these trends related to implementation are important to monitor as CoolThink@JC continues to scale to more schools, this research has not uncovered a cause for immediate concern that is specific to CoolThink's implementation in schools with higher rates of student financial need. The results do, however, suggest larger opportunities for The Trust's focus on promoting educational equity in Hong Kong.

Teachers of higher-ability classes were more likely to report their students were able to complete lessons in the time available and had more opportunities for independent thinking, including identifying problems, generating their own ideas, and designing programs in addition to coding them. Some of these findings are statistically significant, suggesting the CoolThink lessons as designed are more accessible for students who generally perform at or above grade level, and as a result their teachers are somewhat better able to enact CoolThink's opportunities for problem-solving and independent thinking in their classes. CoolThink@JC has begun implementing some supports for diverse abilities in the classroom, such as animations and video to enable home study and revised school-based learning materials, among other strategies. The findings of this research suggest the continued need for additional supports for teachers, to help them navigate the challenges of ability level and available time in ways that are as supportive as possible to students' understanding of computational thinking.

School-level context for CoolThink implementation

Different schools operate with different governance practices and existing curricula, which in turn can support or constrain individual teachers' choices as they adopt CoolThink@JC and computational thinking education more broadly. For example, leaders of each school must decide how to accommodate CoolThink instruction in the school-based curriculum. Teachers' access to high-quality professional development is a key component of each school's capacity to sustain CoolThink@JC in the long term. School leaders' beliefs and commitment are key success factors for sustainability as well, as these can play an important role in driving adoption and supporting high-quality computational thinking education.

Data suggest that additional challenges may emerge as CoolThink@JC expands to schools that have not already been recruited into the network. The vast majority of Hong Kong primary schools already teach ICT lessons to all Primary 4-6 students and have done so for many years. Relative to their out-of-network counterparts, in-network schools have also responded to some different incentives for curriculum adoption, such as the opportunity to participate in CoolThink teacher professional development and the fit between CoolThink@JC and school goals. As early adopters, network schools demonstrated higher levels of readiness than other Hong Kong primary schools to take up CoolThink@JC at baseline, and they have found it necessary to make trade-offs in their schedule to adopt CoolThink@JC. These factors may raise the bar for convincing remaining out-of-network schools that CoolThink@JC is novel and worth the effort to adopt.

CoolThink teacher development courses remain the most important source of training for CoolThink teachers, and teachers who participated in this training reported feeling more prepared to teach CoolThink@JC than their peers who did not. Teachers' confidence in teaching computational concepts, practices, and perspectives has increased over time, especially for teachers who completed multiple development courses and who interacted with mentor teachers; the value they place on computational thinking increased as well. Overall, the combination of CoolThink teaching experience and participation in CoolThink development courses is helping to set teachers and their schools and students up for success.

Development of the CoolThink ecosystem

A key long-term goal for CoolThink@JC is the development of a sustainable, territory-wide ecosystem to support computational thinking education. The Trust has engaged key partners from all sectors of the Hong Kong education system to support CoolThink@JC via participation in its Expert Group, Advisory Committee, and other program committees. Interviews with these partners—all of whom were participating in CoolThink governance in some way—offered evidence of a CTE ecosystem that is continuing to mature.

Across organizations, key system-level actors articulated strong support for CoolThink's mission and the importance of computational thinking in developing problem-solving and other 21st- century skills. Respondents had deep knowledge of the CoolThink initiative and appeared to be strongly invested in the success of CoolThink@JC. Although they spoke of an ecosystem still in development, they emphasized that CoolThink@JC has been a key driver of innovation to improve teachers' professional preparation and encourage CTE adoption, particularly through the key facilitation role played by The Trust. The CoolThink ecosystem beyond the Hong Kong Jockey Club includes multiple mechanisms to support teachers' implementation of CoolThink@JC, including several important collaborations to provide professional development, networks of experienced CoolThink teachers that include InnoCommunity and mentor teachers, supports from universities, supports for schools, and parental outreach. System-level observers believe these development opportunities are particularly essential ways to scale CoolThink@JC and CTE to other teachers who might not otherwise have access to the CoolThink materials. Efforts to build cross-school networks among school leaders are modest to date.

Challenges to scale and sustainability include cost, uncertainty about how CTE fits into existing curricula, teacher turnover, and a possible lack of leadership once The Trust scales back its role in leading scaling efforts. To support continued scaling of CoolThink@JC, respondents highlighted the importance of the Hong Kong Education Bureau (EDB) curriculum policy, identifying an organization to continue leading the CoolThink work, maintaining use of teacher-led communities of practice, and increasing parental outreach. They envision scaling CoolThink@JC to secondary schools and embedding it into additional subject areas as important next steps.

Key Success factors for a successful CTE implementation

Data emerging from this study suggest a number of factors that we expect to be essential to the continued success of CoolThink@JC at scale and, more broadly, to CTE. The research will continue to test these factors as the adoption of CoolThink@JC in network schools continues to mature: for example, the research will look for possible correlations with student outcome data, and whether they are present in pilot schools in which CoolThink implementation is sustained. Based on data at midline, the following are emerging as preliminary factors likely to predict a successful CTE implementation:

1. **Student experience of active learning pedagogy and high levels of engagement with CoolThink lessons.** Based on data so far, CoolThink's active lessons and opportunities for creativity have the potential to inspire students' learning and engagement, particularly in units based on the programming language Scratch.
2. **Access for students to the full range of creative and design tasks that are built into CoolThink@JC, including the final project.** As teachers adapt CoolThink lessons for accessibility and to fit into available time, support and training toward productive modifications rather than simple streamlining can help preserve these important opportunities for creativity and design for all students.

3. **Teacher access to comprehensive professional development on computational thinking and readiness to teach CoolThink@JC.** The professional learning offered as part of CoolThink@JC is proving to be an essential enabler for teachers who are adopting the lessons and must be preserved as CoolThink@JC continues to scale to more schools.
4. **Teacher confidence incorporating computational thinking into their instruction and perspectives on the accessibility of CoolThink materials.** As teachers gain experience with CoolThink implementation, their capacity to integrate computational thinking concepts, practices, and perspectives into their instruction and their experience of CoolThink materials as accessible both for themselves and their students will be important factors driving success.
5. **School leader support for innovation and for the place of computational thinking education in the primary school curriculum.** These important priorities are espoused more strongly among school leaders in CoolThink network schools relative to their counterparts who have not yet engaged, making it a potentially important focus for the initiative moving forward.

This implementation study will continue to research and elaborate on these and other factors for success as CoolThink@JC continues to mature within its network schools and as it supports the expansion of CTE to a broader set of Hong Kong schools in the coming year.

INTRODUCTION

Launched in 2016 and led by The Hong Kong Jockey Club (HKJC) Charities Trust (The Trust), CoolThink@JC is a groundbreaking initiative in Hong Kong that is bringing the study of computational thinking to Primary 4-6 students across the territory. As of early 2023, the CoolThink network had enrolled 204 schools in six cohorts, serving > 90,000 students and exceeding its target of 200 schools that will have adopted the 14-hour curriculum by the end of the scaling period.

Even as it achieves its initial goals of reaching a solid critical mass of Hong Kong's primary schools, HKJC and its development partners are expanding those goals. Hong Kong's Chief Executive has announced a new policy that will roll out enriched coding education to all primary schools in Hong Kong.[1] The Education Bureau will adopt and adapt CoolThink learning materials to further disseminate to all schools. Moving forward, therefore, the CoolThink team is pursuing a two-pronged mission: supporting the continued success of the 204 schools within its network as they adopt the full CoolThink curriculum; and promoting a successful rollout of computational thinking education (CTE) to all remaining Hong Kong primary schools.

This is the second report from SRI International's ongoing study of CoolThink implementation at scale. Based primarily on data collected from Cohort 3 and 4 schools during the 2021–22 schools year, the report examines the status of CoolThink implementation two years into the scaling phase, at midline. This study of CoolThink implementation seeks to support both aspects of CoolThink's current mission, informing our understanding of implementation success both within network schools and beyond.

CoolThink@JC overview

CoolThink@JC is a 3-year course sequence designed to introduce computational thinking to students in the upper primary grades and to support the development of their digital creativity, problem-solving, and other 21st-century skills. Created by The Trust, CoolThink@JC is a collaboration between the Education University of Hong Kong (EdUHK), Massachusetts Institute of Technology (MIT), and City University of Hong Kong (CityU). CoolThink partners developed comprehensive instructional materials, intensive teacher professional development (PD) to support effective CoolThink instruction, and workshops to support public awareness of and parent engagement in CTE. The lessons combine three essential elements of computational thinking (CT): CT concepts, CT practices, and CT perspectives.

Over the course of a 3-year pilot, 32 Hong Kong primary schools adopted CoolThink lessons for more than 20,000 Primary 4–6 students. A rigorous evaluation of the impact of CoolThink@JC on pilot students' CT skills found that CoolThink@JC had a large, statistically significant positive effect on CT practices and a smaller positive impact on CT concepts (Shear et al., 2020). In addition, CoolThink teachers reported that the lesson materials supported

[1] The Hong Kong Chief Executive's 2022 Policy Address included the following policy goals: "More learning elements of I&T [Innovation and Technology] will be incorporated in the curriculum, with the aim of at least 75% of publicly-funded schools implementing enriched coding education at the upper primary level and introducing I&T elements such as Artificial Intelligence in the junior secondary curriculum by the 2024/25 school year." In addition to CoolThink materials, EDB will also adopt AI learning materials from the Chinese University of Hong Kong (CUHK) Jockey Club AI for the Future Project, which is funded and co-initiated by the HKJC Charities Trust.

a shift toward more student-centered pedagogy, greater student autonomy, and more opportunities to express creativity as students learned to define and solve novel problems without a single correct answer.

Building on these results, CoolThink partners began scaling CoolThink@JC to additional primary schools in summer 2020. A third cohort of 47 schools joined the CoolThink network in summer 2020 and a fourth cohort of 52 schools joined in summer 2021, with two additional cohorts recruited to join in 2022 and 2023. Ultimately, the partners intend to support the adoption of CoolThink lessons in a large majority of Hong Kong's 475 public sector primary schools and create a self-sustaining territory-wide ecosystem that will support the continued growth and sustainability of CTE after the HKJC investment ends. By demonstrating success at scale, CoolThink partners hope to create a new paradigm for CTE at the upper primary level that will serve as an international model for other cities and states as they seek to extend CTE to the primary grades.

CoolThink partners have developed a range of scaling strategies designed to make the CoolThink program less resource-intensive, to lower barriers to adoption, and to build capacities for success and sustainability within the system (see box).

CoolThink@JC Key Components

Key components of the CoolThink program as it was designed for scaling include:

- Three 14-hour lesson sequences and accompanying instructional materials that reflect CoolThink's key design principles (e.g., to play, to think, to code, to reflect pedagogy) and incorporate cutting edge technology (e.g., artificial intelligence and robotics).
- Support for school-level tailoring of the CoolThink curriculum, with options for designing specialized course pathways, streamlining lesson sequences, and/or supplementing/enriching lessons.
- Modular foundational teacher development courses that require substantially fewer hours in training compared with teacher PD offered during the pilot phase.
- Mentor teachers who conduct peer observations and provide feedback to teachers who are participating in foundational training.
- Cluster-level communities of practice (CoPs) that convene CoolThink teachers within a geographic region to collaborate, share resources, discuss problems of practice, and observe their peers. CoPs are facilitated by CoolThink mentor teachers.
- Instructional resources, including teaching assistants to support CoolThink instruction during teachers' first year in the program, and subsidies to purchase mobile devices to support instruction using MIT App Inventor.
- An InnoCommunity network of innovative teachers designed to disseminate CoolThink materials and support schools that want to carry out a more limited adoption of CoolThink materials.
- A wide range of additional teacher PD opportunities available to all schools and offered by multiple providers (for example, workshops sponsored by the Hong Kong Education Bureau (EDB) and InnoCommunity workshops led by pilot phase mentor teachers).
- Parent engagement workshops, coding fairs, and student competitions.
- Validated annual assessments of students' CT concepts, practices, and perspectives aligned with CoolThink instructional objectives.
- Strategic partnerships with the EDB, school sponsoring bodies (SSBs), and non-governmental organizations to develop a territory-wide ecosystem in support of CTE.

CoolThink@JC implementation study

To capture the lessons learned from this effort, HKJC has engaged SRI International to study the implementation of CoolThink@JC at scale. This study is designed to:

- Assess the extent to which schools' adoption of CoolThink@JC is consistent with the initiative's design principles and sustained over time,
- Identify the conditions that support or impede successful adoption at the classroom and school levels, and
- Validate an implementation model that will help interested stakeholders to learn from CoolThink's scaling experience.

After the first two years of CoolThink adoption for the 47 schools in the CoolThink network's Cohort 3 and the first year of adoption for the 52 schools in Cohort 4, this implementation report explores what CoolThink@JC looks like at scale, as students and teachers engage in computational thinking instruction, relative to previous ICT instruction and to the CoolThink instructional vision, and what CoolThink adoption looks like at the school level. The report has a particular focus on student and teacher experiences in classrooms of higher need, either in terms of socioeconomics or academics, as educational equity is a primary concern for HKJC. In addition, we include information from interviews of CoolThink stakeholders and a survey of principals at schools that were not part of the CoolThink network to describe the progress of an ecosystem that can support CoolThink@JC at scale in Hong Kong, and factors that may be important to a successful adoption by the full breadth of primary schools in the territory.

The report seeks to address the following research questions:

1. What does a CoolThink classroom look like at scale?
2. Do students' experiences of CoolThink instruction differ in high-need classrooms compared with low-need classrooms?
3. What are the essential characteristics of CoolThink teacher PD at scale? How do teacher perceptions and self-reported outcomes vary in response to scalable models of PD?
4. To what degree is a sustainable territory-wide ecosystem in support of computational thinking in evidence in Hong Kong?

2020–21 data sources and samples

Data collection for the implementation study combines broad-scope surveys of representative samples of CoolThink teachers and school leaders with more in-depth data collection in small, purposive samples (e.g., educator interviews, classroom observations, classroom logs, PD observations, system-level interviews, and out-of-network surveys) to understand how the CoolThink vision is being understood and enacted throughout the various levels of the primary school system. Exhibit 1 on the following page summarizes each data source informing this midline report, the time periods covered, and sample sizes, including response rates. Additional detail on data sources, samples, and methods can be found in the appendix.

Exhibit 1: Implementation study data sources

	Instrument	School year	Sample	Number of respondents/ response rate
Baseline	Cohort 3 baseline teacher survey	2019-20	All Cohort 3 teachers	194 teachers / 79%
	Cohort 4 teacher baseline survey	2020-21	All Cohort 4 teachers	253 teachers / 81%
	Cohort 3 baseline school leader survey	2019-20	All Cohort 3 school leaders	41 school leaders / 87%
	Cohort 4 baseline school leader survey	2020-21	All Cohort 4 school leaders	49 school leaders / 94%
	Out-of-network school leader survey	2019-20	Representative sample of public sector primary schools (aided, direct subsidy scheme, government)	206 school leaders / 51%
CoolThink Implementation, 2021–22 **(Cohort 3 Y2, Cohort 4 Y1)**	Cohort 3 & 4 follow-up teacher survey	2021-22	All Cohort 3 teachers	514 teachers / 82%
	Cohort 3 & 4 follow-up school leader survey	2021-22	All Cohort 4 teachers	80 school leaders / 80%
	CoolThink classroom logs	December 2021– June 2022 (6 monthly logs)	60 Cohort 3 & 4 schools, up to 5 CoolThink teachers and 5 lessons per teacher	908 logs / 61% 279 teachers / 94%
	School site visits	June-July 2022	Purposive sample of Cohort 3 and Cohort 4 schools	29 teachers, 10 school leaders, 83 students in 14 groups in 11 schools
	System-level interviews	Summer 2022 – Fall 2022	Purposive sample	11 participants across 10 organizations

COOLTHINK CLASSROOMS AT SCALE

The 32-school pilot that took place from 2016-2020 established CoolThink@JC as a successful instructional initiative, distinguished by its student-centered approaches and support for student computational thinking and problem-solving skills (Shear et al., 2020). Scaling to a larger set of schools brings new challenges and asks a more diverse set of educators to adopt the student-centered teaching practices on which the CoolThink design is founded. This section of the report looks at the CoolThink classroom at midline, to describe student learning opportunities at scale and whether they remain consistent with CoolThink's original design goals.

Student participation in CoolThink courses

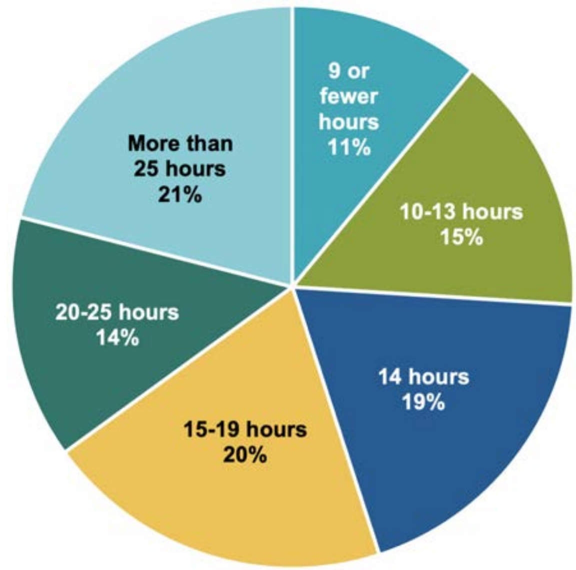
By design, the CoolThink curriculum consists of 14-hour lesson sequences. Each individual lesson is designed to be completed within a 35-minute class period. One of the important factors that might vary at scale is dosage: are schools able to devote the full 14 hours to CoolThink@JC in their instructional schedule, and to complete all lessons as designed in the available time?

In the 2021-22 school year, the question of dosage remained complicated by school schedules that were impacted for at least part of the year by COVID, although to a lesser degree than in the previous year. While the percentage of surveyed teachers who reported having fewer hours available for CoolThink instruction due to COVID-related schedule changes decreased from spring 2021 (74%) to spring 2022 (58%), fully 52% of logged CoolThink lessons in the 2021-22 school year had been shortened to some degree because of COVID. Similarly, on the 2022 survey fewer teachers reported having taught CoolThink@JC online at some point during the school year (77%, vs 90% in 2021); however, 26% of lessons that teachers logged were still taught online, with 6% in a hybrid mode. This continued need to adapt to atypical schedules and settings likely affected CoolThink's implementation to some degree.

Most network schools were able to allocate the full recommended time for CoolThink@JC in their school schedules.

Despite COVID-related schedule restrictions, students in a small majority of classrooms received more than the required 14 hours of instruction. On surveys, 55% of teachers estimated spending more than 14 hours on CoolThink instruction for a given class, while 19% dedicated exactly 14 hours to the lessons. Most of the 26% of teachers who spent less than 14 hours reported that schedule disruptions had gotten in the way.

Exhibit 2: Hours spent on CoolThink instruction during the 2021-22 school year



n = 503

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

Among the teachers who reported devoting 15 or more hours to CoolThink@JC, most indicated they had done so because, in their experience, students needed the extra time. The most commonly chosen explanations were that lessons as designed generally required more than a 35-minute period to complete (59% of teachers), additional instructional time was required to support the needs of diverse students (52%), they provided students with extra time to work independently on programming (46%), or they needed to spend extra time teaching key concepts and helping students understand the content (37%). These findings of additional time requirements were echoed in the classroom logs teachers completed to document a single CoolThink class period: when asked how much time during this class was devoted to CoolThink@JC, 60% of logs reported a duration longer than 35 minutes (either the full length of a double period, a duration in between single and double, or in a few cases even longer).

One teacher explained,

> *Sometimes the lesson is rushed, especially the face-to-face lessons. The modules at the beginning are easier for students, but the games are becoming more complicated later, they need more time to find the right tabs.*
>
> – CoolThink teacher

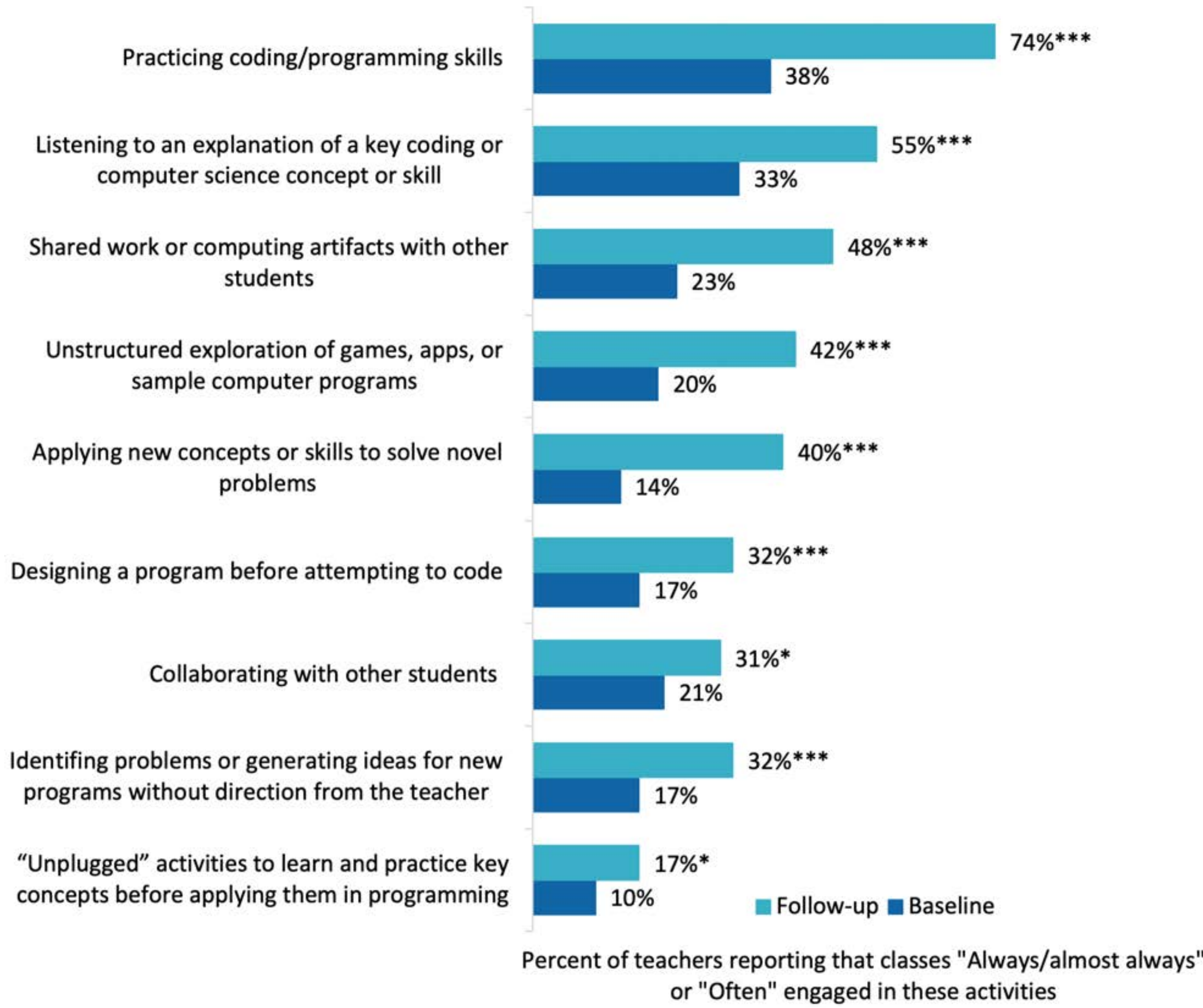
Student experience of CoolThink pedagogy

CoolThink's design principles include weaving the "to play, to think, to code, to reflect" pedagogy across lesson activities to engage students actively in their learning as they develop computational thinking skills. While learning materials guide the lesson, the curriculum offers teachers flexibility to adapt to the needs of their students, their setting, and their own teaching background. As a result, the implementation of CoolThink@JC at scale, and students' experience of it, might vary from the original design. This implementation study investigated the character of the student learning experience in CoolThink classrooms.

In comparison with ICT classes taught prior to CoolThink@JC, students' CoolThink classes focused significantly more time on programming-related topics and included significantly more frequent active pedagogies related to computational thinking.

On surveys, teachers were asked at baseline to rate the frequency of student activities in their prior ICT classes that related to programming (e.g., practicing programming; listening to an explanation of coding or computer science concepts and skills), including a series of activities consistent with CoolThink's active pedagogical design (e.g., unstructured exploration of games apps, or computer programs; designing a program before attempting to code). Later, the teachers were asked to describe the frequency of a similar list of activities in their CoolThink classes. Teachers reported that each of these activities took place significantly more frequently in their CoolThink classes than in prior ICT instruction.

Exhibit 3: Frequency of classroom activities related to programming and computational thinking, baseline and follow-up



**p < .05, **p <.01, ***p < .001*

n = 260

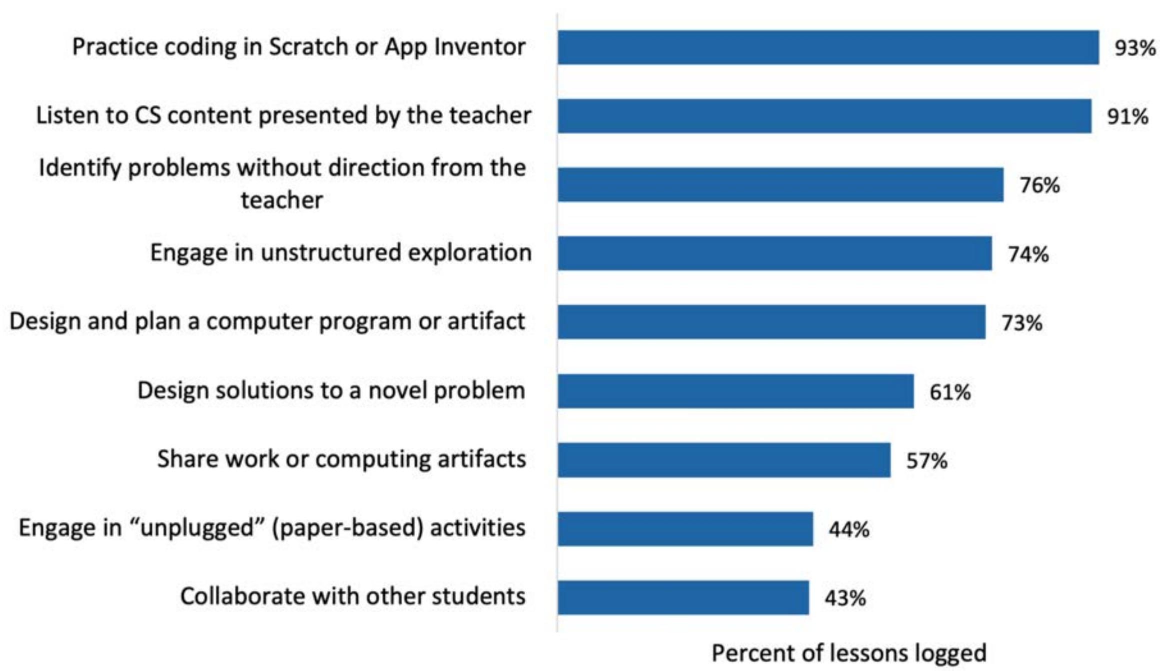
Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

This analysis suggests that as CoolThink@JC scales, students' learning experiences continue to include more content and more active pedagogies related to programming and computational thinking than in prior ICT instruction.

Most CoolThink classes include a variety of CoolThink-aligned pedagogies.

For more information about how students spend their time in CoolThink classes, teachers submitted classroom logs that described the students' activities in a particular CoolThink class. Among the collected logs, practicing programming in Scratch or MIT App Inventor (93%) was the most common learning activity in CoolThink classrooms, followed by listening to the teacher's explanations of a key coding or computer science concept or skill (91%). Another set of activities aligned with CoolThink pedagogies (identifying problems without direction from the teacher; unstructured exploration of games, apps, or sample computer programs; designing and planning before attempting to code; designing a solution to a novel problem; and sharing their work with other students) were present in more than half of the logged lessons.

Exhibit 4: Percent of lessons logged that included CoolThink-aligned activities

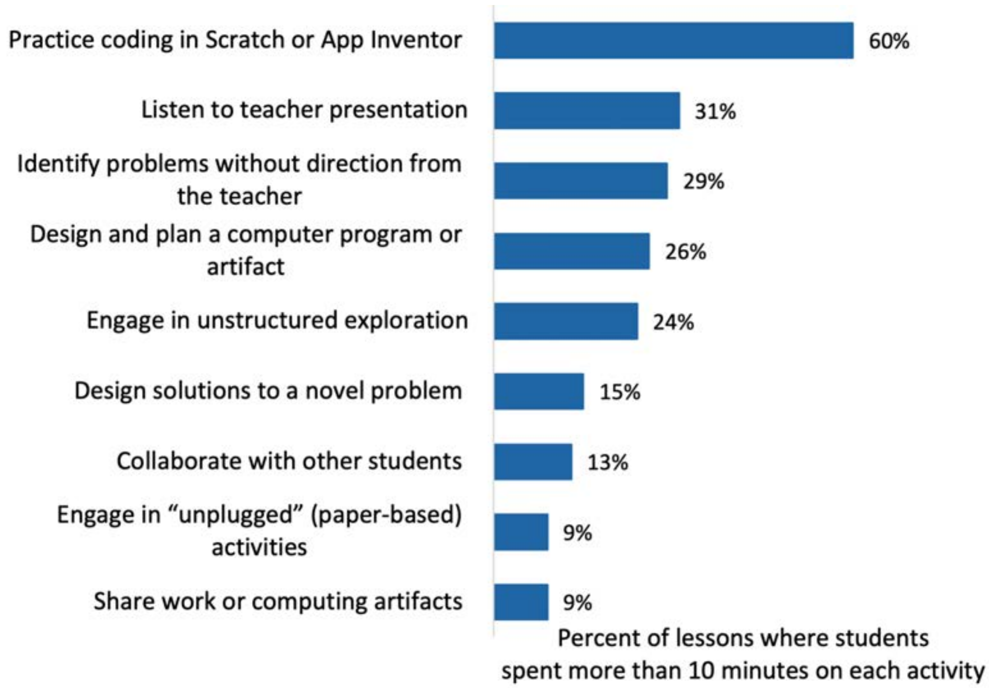


n = 896

Source: CoolThink classroom logs, 2021–22

Logs also asked teachers which of these student activities were longer than 10 minutes in duration in a given class, as an indication of more substantive focus. By this measure, the top activity remained practicing coding (which students did for more than 10 minutes in 60% of the 908 logged lessons). The more passive activity of listening to the teacher was next frequent at 31%, with three more CoolThink-aligned activities (identifying problems without direction, designing and planning a program, and unstructured exploration) each present for more than 10 minutes in over a quarter of logged lessons.

Exhibit 5: Percent of lessons logged that included CoolThink-aligned activities for more than 10 minutes



n = 716

Source: CoolThink classroom logs, 2021–22

The most common student activity in CoolThink classes – coding – can be taught in a variety of ways that can represent either active or passive student learning. The balance of these contrasting approaches varies substantially across teachers. For example, in one class students might be given opportunities to test their code and diagnose/fix problems on their own, with the teacher providing hints to encourage students to think through the challenges they were facing. In another class students might work through a detailed set of steps, asking the teacher for help when they get stuck.

We would try to think more and try by ourselves to solve problems.
– CoolThink student

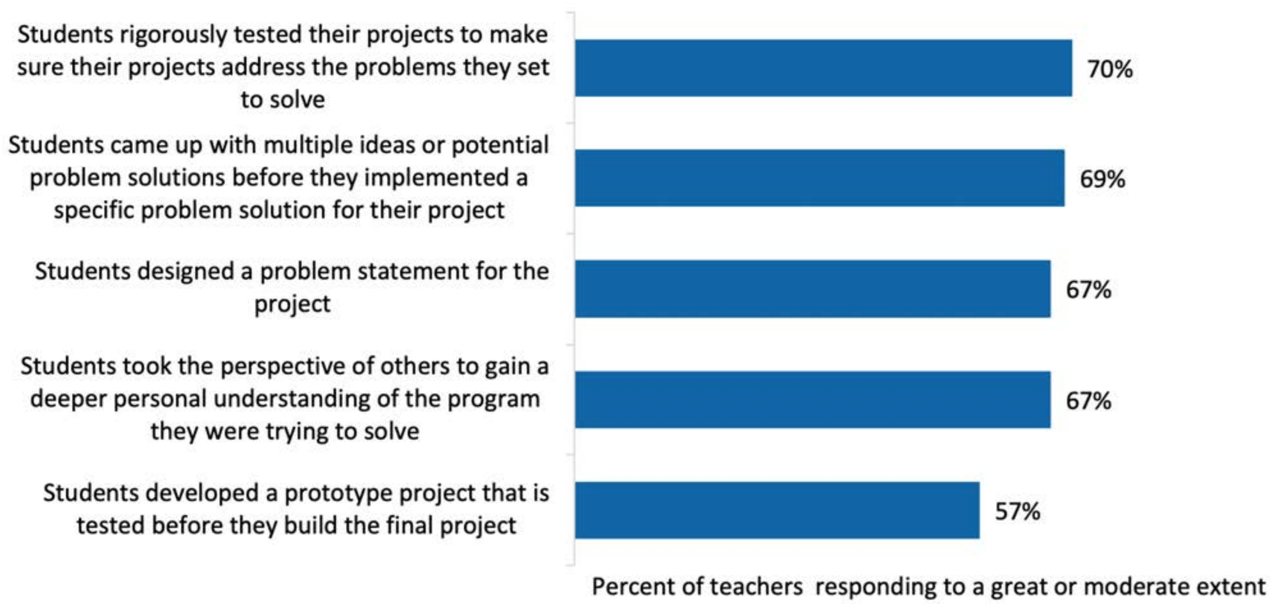
We solve problems by asking the teacher. Sometimes we ask our classmates as well.
– CoolThink student

In the 541 submitted logs in which students practiced coding for more than 10 minutes, 75% of these logs also included another CoolThink-aligned activity (such as identifying problems independently or engaging in unstructured exploration) for at least 10 minutes as well. This suggests that the majority of classes in which students spent a substantive amount of class time coding included some amount of opportunity for student-directed learning.

> *[My typical process is] to play and try the game first, then to introduce the game and concept with a PowerPoint, and then code together. Students would try the game lastly.*
> – CoolThink teacher, describing the typical flow of a CoolThink lesson

Another essential feature of the CoolThink curriculum is that it gives students opportunities for design thinking, which is an essential aspect of problem solving and innovation. Data from the teacher survey suggest that during work on their final project, students in about 2/3 of CoolThink classrooms had an opportunity to decide on a problem to focus their design work on, elaborate their understand of the problem through others' perspectives, generate multiple possible solutions, and test their project to make sure it met requirements.

Exhibit 6: Design thinking in final projects



n = 434

Source: Cohorts 3 & 4 follow up teacher survey, summer 2022

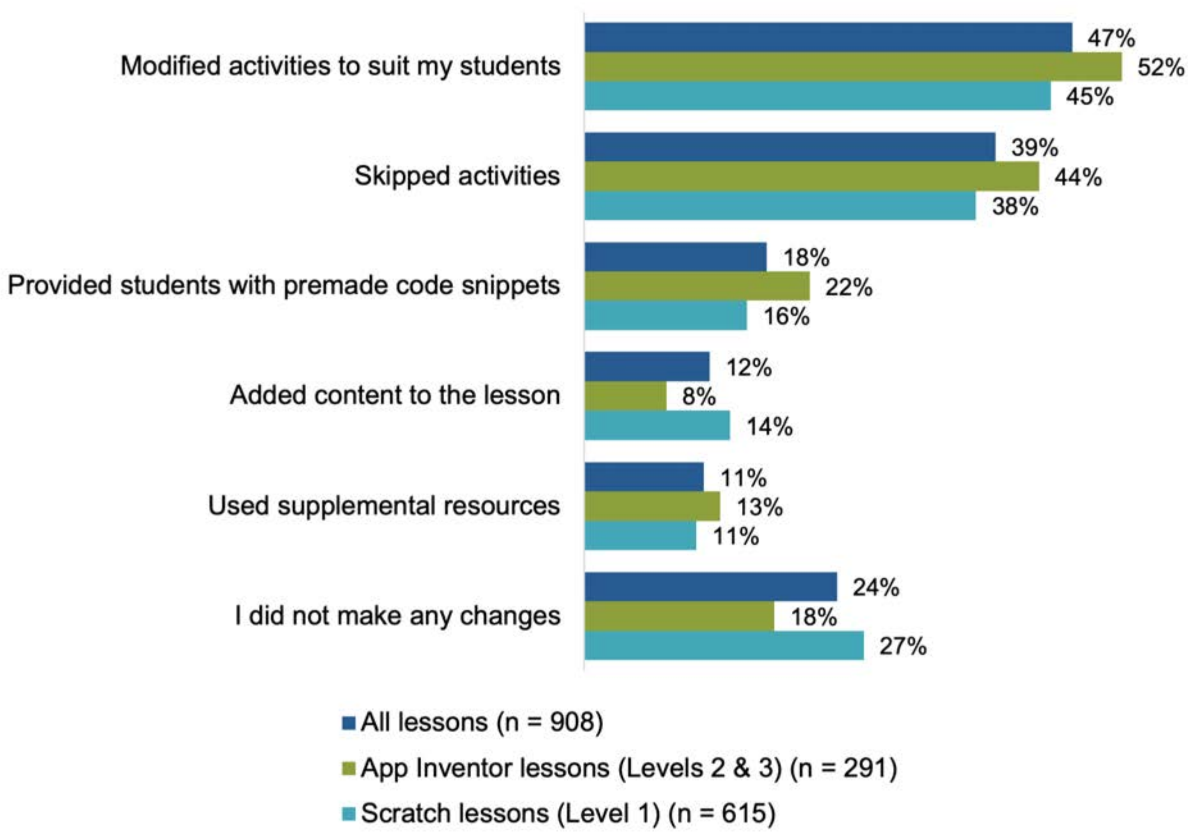
Modifications to CoolThink lessons

By design, CoolThink@JC allows teachers to modify lessons to meet the needs of their students and their schedule. This freedom is particularly important for success at scale, as it can allow a wider range of teachers to integrate the lessons into their own classrooms. It can also bring risks, as some types of modifications may shape students' learning experiences in ways that do not support designers' goals. In this section, we describe the extent of teacher modifications to CoolThink lessons in classrooms at scale and the degree to which those modifications are likely to be productive or counterproductive in terms of students' conceptual understanding of computational thinking.

Teachers reported modifying CoolThink materials in three-quarters of logged lessons (76%).

In general, teachers were more likely to modify or skip activities than to add content or use supplemental resources. Modifications of all types were more common in App Inventor lessons than in Scratch lessons.

Exhibit 7: Modifications to CoolThink materials, by lesson type



*~p < .10, *p < .05, **p < .01, applied to differences between App Inventor lessons and Scratch lessons.*

Source: CoolThink classroom logs, 2021–22

In teacher interviews, the most common reasons cited for making modifying the materials were time constraints (e.g., feeling the need to skip activities to save time) or providing more support to students. For example, one teacher scaffolded the final project by letting students add elements to a given module instead of starting from scratch; another simplified some activities by eliminating some of the more complicated steps.

> *I may share some of my work (50-70% completed) with them and ask them to complete the tasks. This is to lower the difficulty for [students].*
> – CoolThink teacher

Modifications sometimes prioritized task completion over problem solving or conceptual understanding.

On the teacher survey, 64% of teachers rated "Too much content for a short amount of time" as either "challenging" or "very challenging," with App Inventor teachers slightly more likely to report that lack of time is a challenge (67% compared with 61%, although this difference is small and not statistically significant). This concern illuminates the choices that many teachers face every day, when their students are unable to complete the full lessons as designed in the time allotted. Some teachers choose to carve out enough time in class for students to explore issues and solve problems on their own, a strategy that prioritizes conceptual understanding even if it means students are not able to complete their programming task during class time.

But according to interviews with CoolThink teachers and the mentor teachers that observe them, lesson adaptations more commonly reduce the intellectual challenge or the time-consuming steps of problem identification and problem solving to support students' abilities to complete their programs successfully. Mentor teachers drew a distinction between modifications that were "productive" toward deeper understanding vs. those that were "unproductive", such as leading students through the steps to make it more efficient. Productive alternatives they suggested included a "flipped classroom" approach, a common element of some CoolThink classes that assigns students some of the more rote activities to do at home so as to save class time for problem solving and deeper thinking, or providing code snippets designed not just make the coding task easier, but to allow students to build conceptual understanding by deeply engaging them on a particular aspect of the project while still allowing them to complete a working program.

> *I put more time into letting students "try" rather than teaching and explaining the theories because I think letting the students try coding is more important for CoolThink.*
> – CoolThink teacher

> *Some of the parts are too difficult for the students, so we may simply ask the students to drag the blocks directly, we didn't explain it in a very detailed way as it is too complicated.*
> – CoolThink teacher

Student experiences and outcomes

Students reported enjoying many aspects of CoolThink@JC: in particular, the unstructured play, games, and opportunities to be creative.

Site visits to schools included discussions with groups of students so that we could include the perspectives of CoolThink's most important stakeholders. Most student groups rated their overall experiences with CoolThink@JC as positive. In particular, students said that games were fun and interesting, and many said they enjoyed coding and story creation. Some students also noted that CoolThink@JC is inspiring them to pursue an ICT-related career, such as programming or a future in game design.

> *I like playing and making the game because I learned many new concepts and I can also create the game in my own way.*
>
> – CoolThink student

> *I thought coding was difficult at first, but I find it interesting and not as difficult as I imagined.*
>
> – CoolThink student

> *I am thinking of developing my career path in coding related areas.*
>
> – CoolThink student

> *I can also be a game creator, which is interesting.*
>
> – CoolThink student

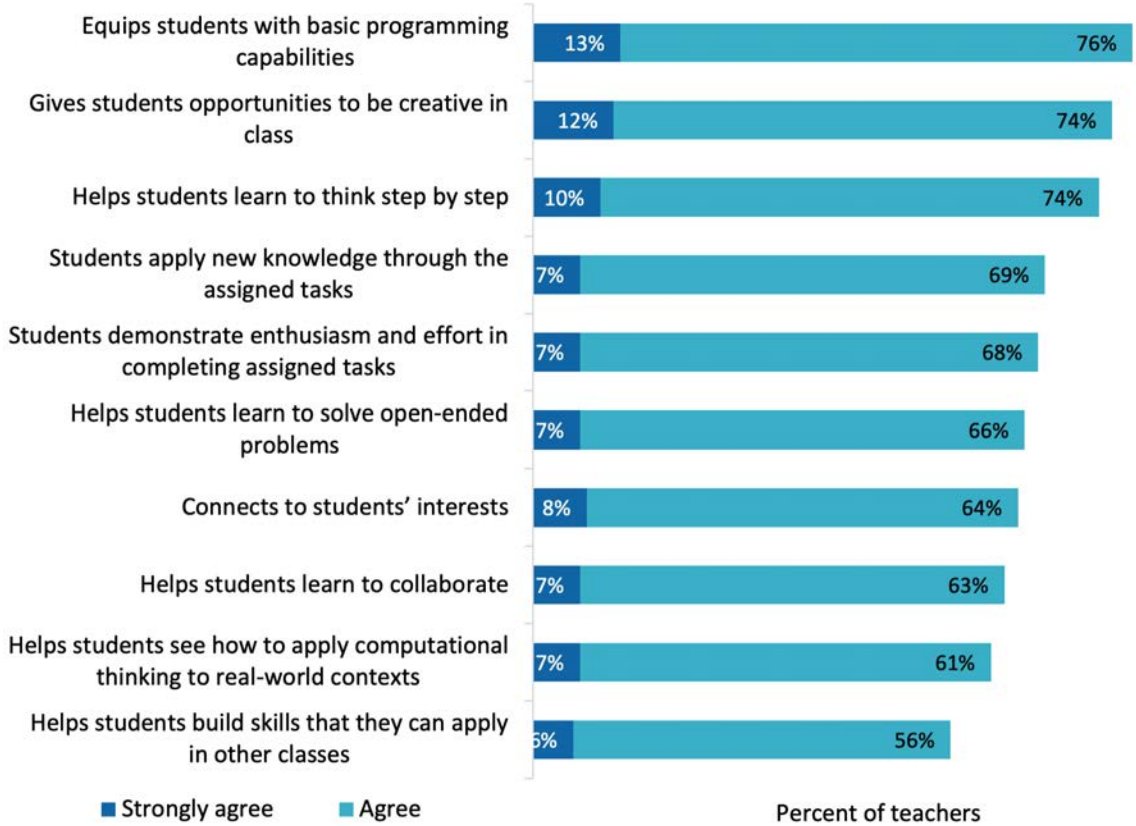
Teachers echoed this positive reflection of student engagement on the survey: 75% of them "agreed" or "strongly agreed" that students demonstrate enthusiasm and effort in completing assigned tasks, and 73% that CoolThink@JC connects to students' interests. In interviews, teachers reflected that students are interested and excited about making their own games, they are engaged or focused, they enjoy coding, and they are happy in their CoolThink classes.

> *They enjoyed To Play the most, but it is meaningful for the coding later as they have a basic picture for the game or app they are going to make.*
>
> – CoolThink teacher

The vast majority of teachers believe that CoolThink@JC has benefitted their students in multiple ways.

On surveys, a large majority of teachers agreed with a variety of statements about possible ways in which CoolThink@JC might benefit their students. In particular, 89% of teachers overall agreed or strongly agreed that CoolThink@JC equips students with basic programming capabilities; 86% that it gives students opportunities to be creative in class; and 84% that it helps students learn to think step by step. Teachers were somewhat less likely to agree that CoolThink@JC benefits students by helping them transfer skills to other contexts (by learning to apply computational thinking in real-world contexts (68%) or building skills that can be applied in other classes (62%).

Exhibit 8: Teacher-reported student benefits



n = 499

Source: Cohorts 3 & 4 follow-up teacher survey, summer 2022

As described earlier, enacted CoolThink lessons vary as to the degree to which students are solving their own problems or following instructions that lead them through each step. Commensurate with these differences in the character of students' learning opportunities, and despite high levels of agreement on many outcomes related to programming abilities, some teachers report that in their experience evidence of deeper conceptual understanding remains elusive.

> *Regarding coding, students can follow the steps but they may not understand the logic and concepts behind it. I would say, out of one class, only five students may understand the logic.*
>
> – CoolThink teacher

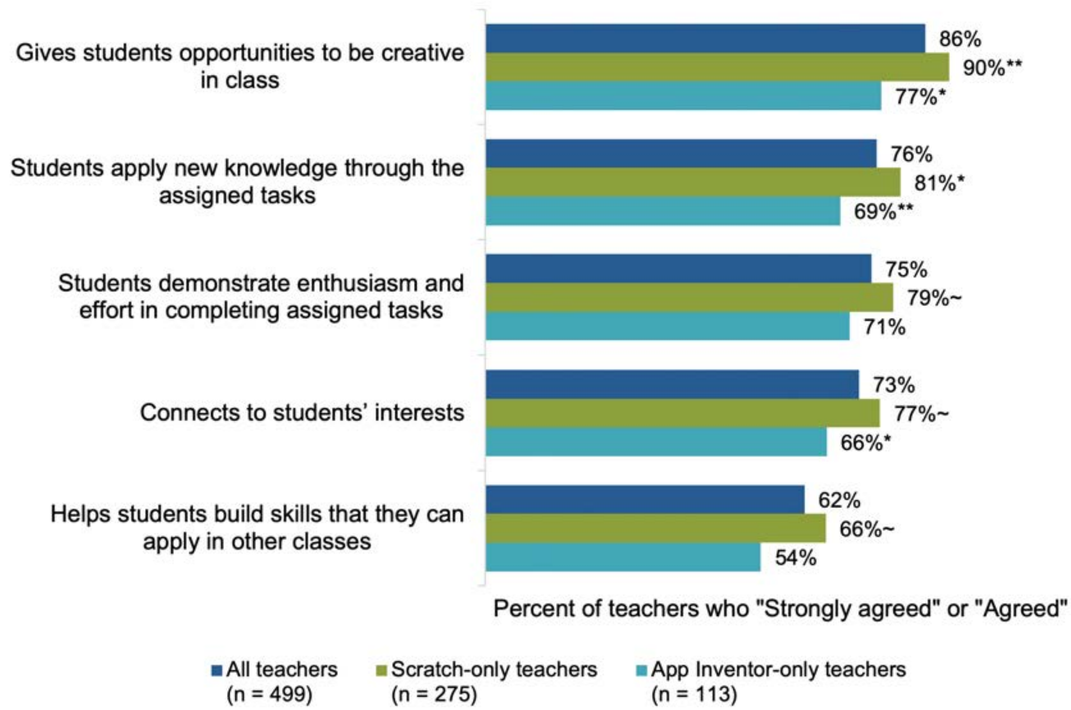
> *Our students struggle to come up with their own innovative solutions. Most of them follow the instruction step by step, applying the same programming concepts in the same way to complete the task. They may not be capable to think of alternatives to solve the problem.*
>
> – CoolThink teacher

Many CoolThink teachers and students find Scratch more accessible than App Inventor.

In the CoolThink curriculum sequence, Level 1 classes (typically involving students in Primary 4) use the Scratch computing platform, and Levels 2 and 3 (typically Primary 5 and 6) use MIT App Inventor. Of the Cohort 3 teachers in their second year of teaching CoolThink@JC, 61% indicated their second year was harder than their first, compared to 10% who felt it was easier, and 29% who experienced no difference. The most common reason they gave for experiencing more difficulty in the second year was that Level 2 lessons are more difficult to teach (79%); 66% also agreed that App Inventor is a more difficult programming language than Scratch. Consistent with this finding, teachers at baseline were much more likely to have experience teaching in Scratch than App Inventor.

Commensurate with these challenges, teachers' ratings of student benefits were consistently lower among teachers of MIT App Inventor compared with Scratch (Exhibit 9). App Inventor teachers were significantly less likely to say that CoolThink@JC gives students opportunities to be creative in class or to apply new knowledge through assigned tasks, or that it connects to students' interests. Consistent with experiences in the CoolThink pilot (Shear et al., 2020), teachers and students indicated in interviews that Scratch is a more accessible tool for many primary students, making class activities more engaging and problem-solving more attainable.

Exhibit 9: Teacher perceptions of student benefits, by lesson type



*~p < .10, *p < .05, **p <.01*

Source: Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

Despite these challenges, on average CoolThink@JC continues to receive high accolades from both students and teachers as they engage in this novel form of CTE.

EQUITABLE ACCESS TO HIGH-QUALITY COOLTHINK INSTRUCTION

Equity of educational opportunity for all students in Hong Kong is of primary importance to the Hong Kong Jockey Club. CoolThink@JC is taught as part of the regular school day, ensuring that computational thinking education is available to primary grade students in all circumstances. In addition, it is important to ensure that all students have a chance to engage in the same high-quality educational experience in their CoolThink classes, with similar opportunities for problem-solving and CoolThink-aligned pedagogies.

In this research, we used two primary methods for looking at equity. At the school level, we divided schools into groups based on the percent of students participating in the government financial assistance scheme. These data were collected by Ipsos from network schools for the 2022–23 school year.[2] We defined "high-need" schools as those with more than 45% of students receiving financial assistance (14 Cohort 3 and 4 schools with 69 teachers). We defined "low-need" schools as those in which 15% or fewer students received financial assistance (13 schools and 68 teachers). The distribution of schools and teachers in these groups is shown in the table below.

Exhibit 10: Distribution of students receiving financial assistance in Cohort 3 and 4 schools

Group	Number of schools	Number of teachers	Min	Max	Mean	SD
1 (low-need, 15% or less	13	68	1	12.7	5.8	4.1
2 (15% to 30%)	34	189	17.2	30.0	23.8	3.5
3 (30% to 45%)	34	177	30.2	45.0	37.9	3.9
4 (high-need, more than 45%)	14	69	46.0	60.0	52.9	3.6
Total	**95**	**503**				

Source: Ipsos data collection from CoolThink schools, 2022–23

In the exhibits that follow, we show the overall average for each response as well as the averages for the highest and lowest financial aid groupings. In some cases there is not a clear pattern across the three lowest quartiles, resulting in an overall percentage that may be higher than either the highest or lowest quartile on its own. Please see the appendix for exhibits that include all four groups.

At the classroom level, we added a focus on ability groupings. The classroom log asked teachers to estimate the number of students in the class they

[2] 15 schools were missing data in 2021–22. We chose to use the more complete dataset from 2022–23 to preserve sample size.

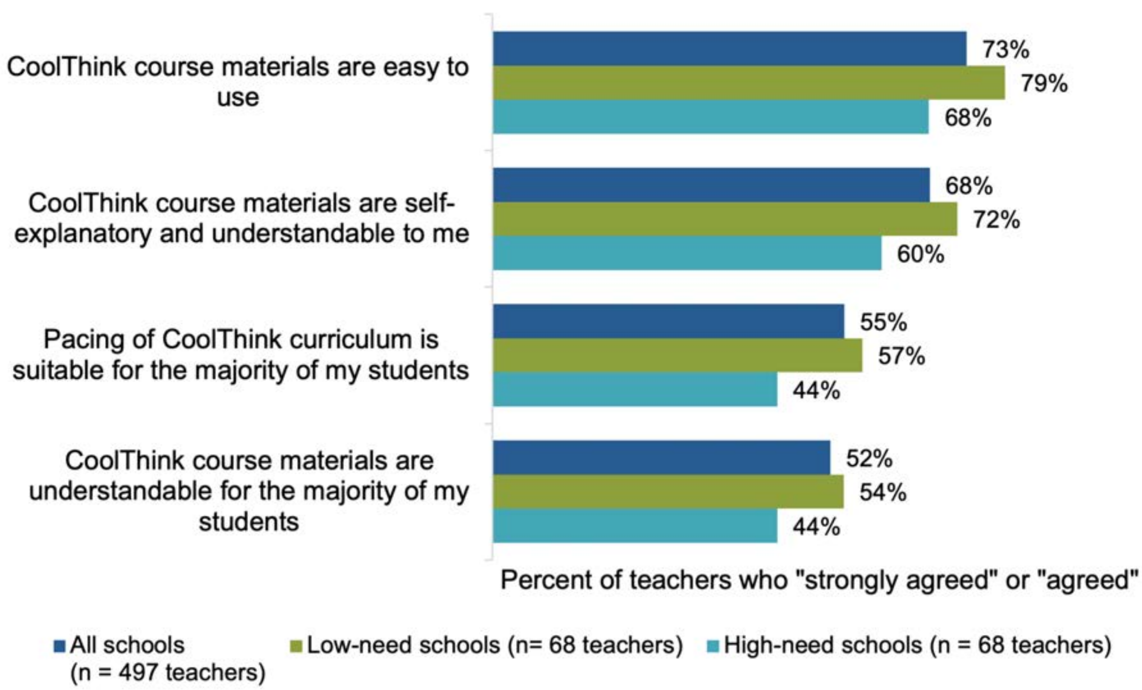
were describing that typically perform at, above, or below the grade level standard. Based on the relative percentage of students at each level, we classified each classroom into higher-ability (n = 225), average-ability (n = 432), and lower-ability (n = 229) groupings (see appendix for additional detail). We also used the school-level financial aid data described above to categorize each classroom.

Students' experiences with CoolThink instruction differed somewhat depending on financial need, as measured by school-level financial aid rates. Although these differences were consistent across many measures of CoolThink implementation, most were not large or statistically significant.

Teachers in schools with high financial aid rates generally described CoolThink@JC as more challenging for their students than did teachers in lower-need schools. For example, teachers in high-need schools were somewhat less likely to report (Exhibit 11) that the pacing of CoolThink materials was appropriate for the majority of their students, or the course materials were understandable for them.

While teacher-reported pedagogy in high-need schools was not significantly different than in low-need schools, trends suggest students in these schools somewhat more frequently listened to their teacher explain concepts, and somewhat less frequently engaged in coding, unstructured exploration, or applying new concepts and skills to novel problems (Exhibit 12). These changes are consistent with the compromises (described above) that teachers often make when they must navigate trade-offs between student-directed learning and students' successful engagement with the lessons in the time available.

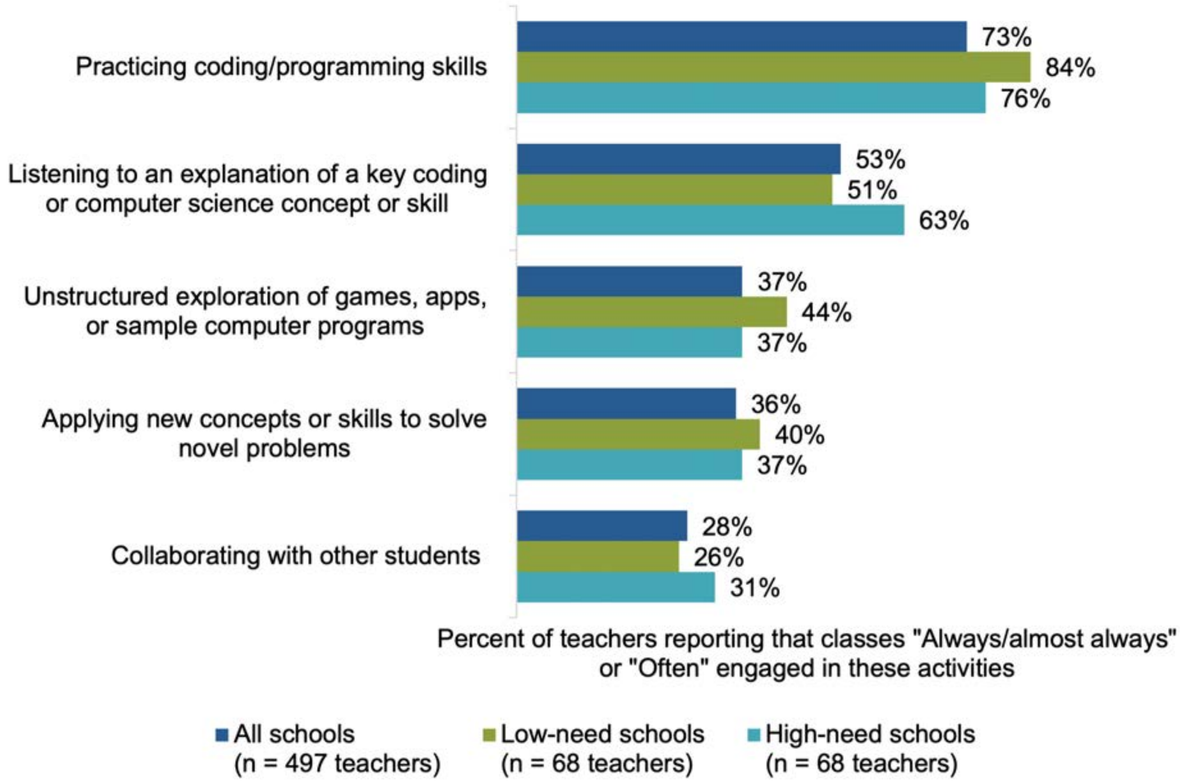
Exhibit 11: Teacher perceptions of CoolThink materials, by school financial aid



*~p < .10, *p < .05, **p <.01, applied to the difference between low-need and high-need schools.*

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

Exhibit 12: Frequency of classroom activities, by school financial aid



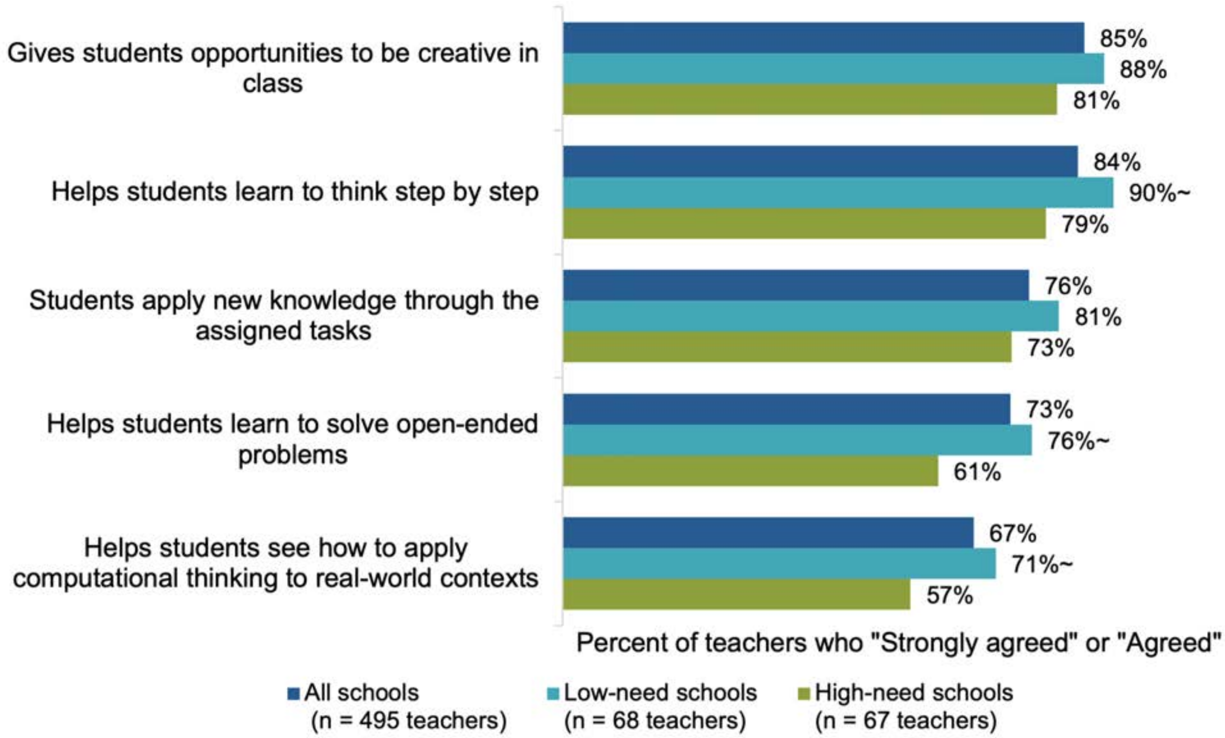
*~p < .10, *p < .05, **p <.01, applied to the difference between low-need and high-need schools.*

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

Perhaps related to these trends in implementation, teacher reports of student benefits from CoolThink@JC were generally stronger in low-need schools (Exhibit 13). On surveys, teachers in high-need schools were significantly less likely to agree that CoolThink@JC helps students think step by step, learn to solve open-ended problems, and apply computational thinking to real-world contexts. Teachers in these schools were also less likely to agree that CoolThink@JC gives students opportunities to apply new knowledge or be creative in class, although these differences were not as strong.

This set of results suggests CoolThink instruction in high-need schools may be somewhat more challenging than in their lower-need counterparts, with materials that may be difficult for students to access and instruction that may be less student-centered, resulting in some compromise in the strength of student outcomes. As a whole, however, many of these relationships are not large enough for statistical significance. In addition, it is difficult to isolate the influence of CoolThink lesson design on these results, as wider contextual influences at high-need schools can also result in disadvantaged learning opportunities and outcomes across the curriculum. While these trends are important to monitor as CoolThink@JC continues to scale to more schools, this research has not uncovered a cause for immediate concern that is specific to CoolThink's implementation in high-need schools.

Exhibit 13: Teacher-reported student benefits, by school financial aid



*~p < .10, *p < .05, **p <.01, applied to the difference between low-need and high-need schools*

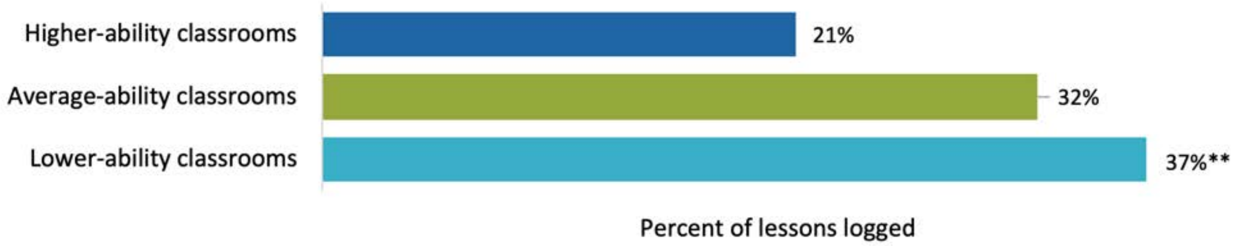
Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

Lower-ability CoolThink classrooms reported additional challenges.

In classes that serve lower-ability students, teachers were significantly more likely to report on logs that they had run out of time to cover planned content as compared with higher-ability classrooms (Exhibit 14); they were also less likely to report they were able to complete a full lesson.

As teachers tried to support their lower-ability students' progress through the materials in the time available, their choices sometimes led to reduced opportunities for students to take on the activities within the CoolThink lessons that demanded independent thinking. According to classroom logs (Exhibit 15), students in lower-ability classes were significantly less likely to spend more than 10 minutes identifying problems and generating their own ideas, and to be responsible for program design as well as coding execution.

Exhibit 14: Insufficient time to complete lessons, by student ability

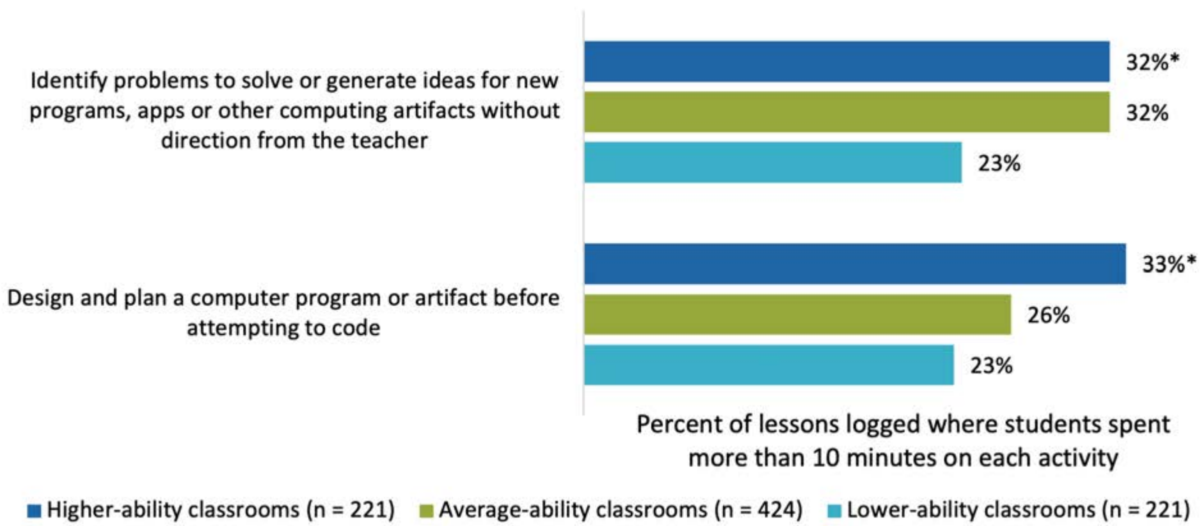


Lower-ability classrooms n = 229; Higher-ability classrooms n = 225; Average-ability classrooms n = 432

*~p<.10 *p < .05, **p <.01, ***p < .001, applied to differences between lower-ability and higher ability classrooms.*

Source: CoolThink classroom logs, 2021–22

Exhibit 15: Classroom activities >10 minutes, by student ability



*~p < .10, *p < .05, **p <.01, applied to differences between lower-ability and higher ability classrooms.*

Source: CoolThink classroom logs, 2021–22

These trends suggest the CoolThink lessons as designed are somewhat more accessible for students who generally perform at or above grade level, and as a result their teachers are better able to take advantage of CoolThink's opportunities for problem-solving and independent thinking. In interviews, teachers explained that some students completed activities by following step-by-step directions without engaging in self-directed problem-solving:

As my class is a weaker class, the students cannot even follow the basic instructions. [For example], they will mix up the blocks for background and those for characters… Some of the students copy my work only, without their own thinking.

– CoolThink teacher

These challenges were especially pronounced for the final project and other tasks that required novel solutions or designing a program from scratch, rather than working from a model or template.

> *We selected one module as the foundation [for the final project] and invited students to add additional elements to it, which is different from the original final project assignment. That requires students to build a work from zero, which is difficult for primary students.*
>
> – CoolThink teacher

Like the differences reported in high-need schools, these issues are not consistently observed across teachers. While most of the teachers of lower-ability and special educational needs (SEN) students indicated in interviews that their students struggled with the basic activities of CoolThink@JC, there were also indications that CoolThink@JC draws on a different set of student talents than does regular instruction, which can be beneficial to some. As one teacher noted:

> *It is too early.. to see any significant differences,... [but] some students with weak academic backgrounds perform really well in CoolThink class. I believe this curriculum helped us to discover some of the potential of our students.*
>
> – CoolThink teacher

SCHOOL-LEVEL CONTEXT FOR COOLTHINK IMPLEMENTATION

Different schools operate with different governance practices and existing curricula, which in turn can support or constrain individual teachers' choices as they adopt CoolThink@JC instruction and computational thinking education more broadly. Leaders of CoolThink schools make curriculum adoption decisions weighing factors both internal and external to the school. Sometimes these include difficult choices about how to accommodate CoolThink instruction in the school-based curriculum, especially when the school day is shortened by COVID-related closures. Teachers' access to high-quality professional development is a key component of each school's capacity to sustain CoolThink@JC in the long term, as are school leaders' beliefs about the value of computational thinking education.

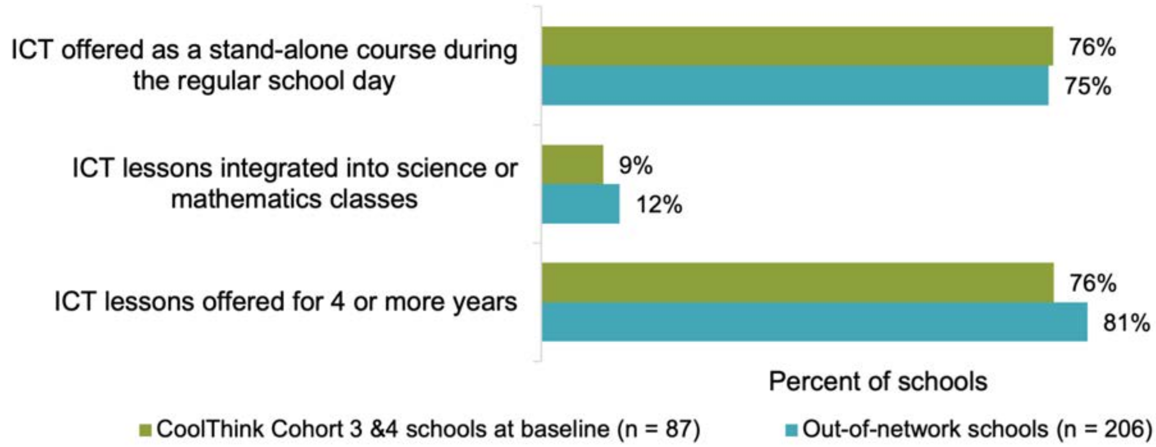
The Trust and its partners anticipated that the first two cohorts of CoolThink network schools, as early adopters, might differ systematically from other schools that did not volunteer to join the CoolThink network. To test these assumptions, this section compares CoolThink schools—at baseline and in spring 2022—with other Hong Kong primary schools that are not part of the CoolThink network ("out-of-network" schools).

School adoption of computational thinking curriculum

CoolThink@JC is scaling in a context where the vast majority of Hong Kong primary schools teach ICT lessons to all Primary 4-6 students and have done so for many years.

At baseline, nearly 90% of Hong Kong primary schools offered some form of ICT instruction to Primary 4–6 students during the regular school day (Exhibit 16). Most primary schools (3 out of 4) offered ICT as a stand-alone course, with a small number of additional schools offering ICT lessons integrated into other classes. Topics most commonly addressed in ICT lessons included programming and logical thinking, software programs and apps, computational thinking, and cybersecurity, with no significant differences between in-network and out-of-network schools (see appendix).

Exhibit 16: Experience with ICT instruction at baseline, CoolThink@JC vs. out-of-network schools



*~p < .10, *p < .05, **p < .01. There are no significant differences between in-network and out-of-network schools.*

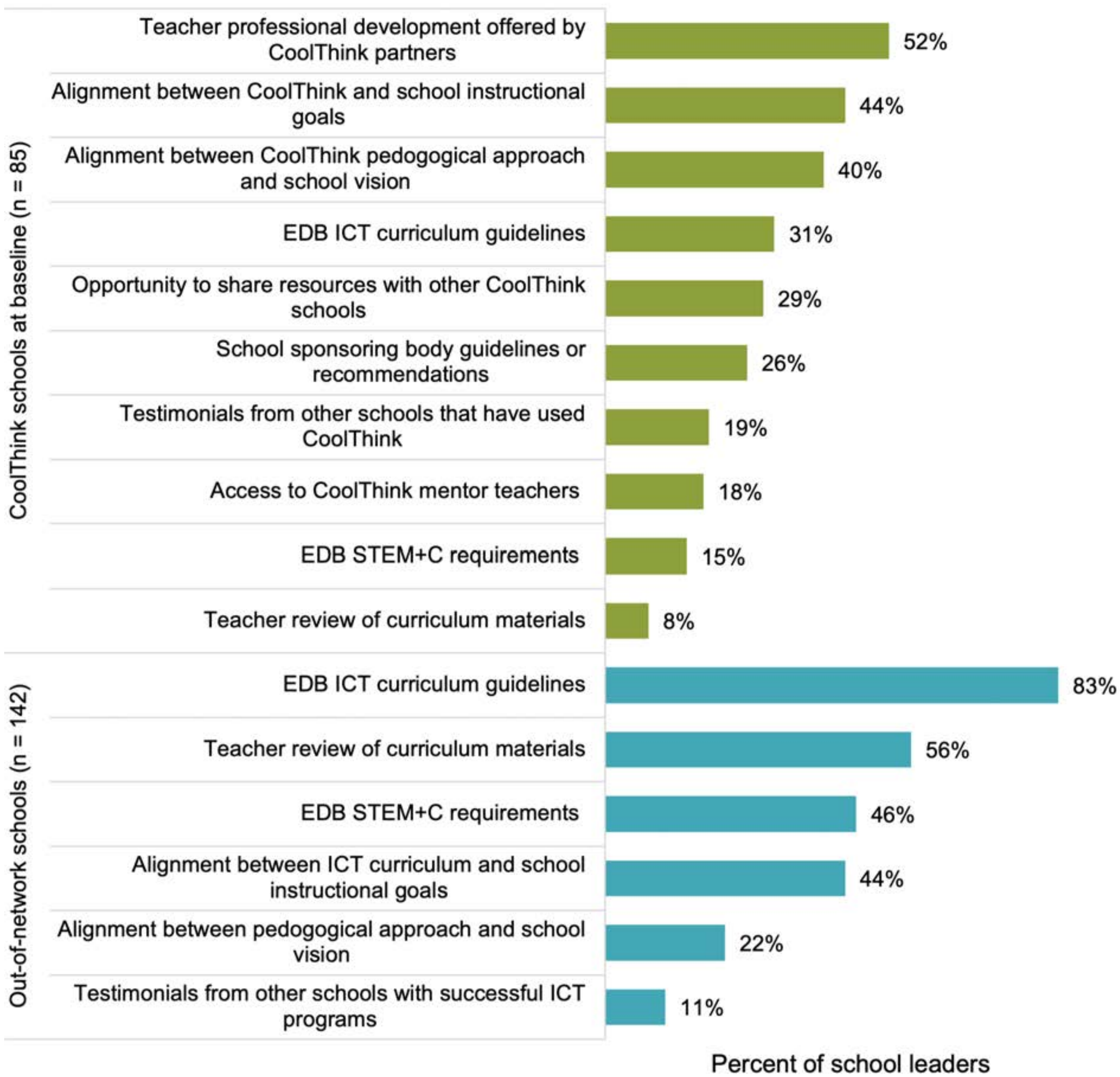
Source: Cohort 3 baseline school leader survey, 2019-20; Cohort 4 baseline school leader survey, 2020-21; Out-of-network school leader survey, 2019-20

The supply of ICT curriculum materials in Hong Kong is robust, with many options available. Some of the most widely adopted materials are published by organizations with a similar stated mission of supporting CTE in Hong Kong. In 2019–20, Hong Kong primary schools were using ICT curriculum materials produced by more than 30 different external developers and commercial publishers (see appendix). Nearly a quarter of schools used their own teacher-developed curriculum materials. Among CoolThink teachers, 40 percent reported using ICT curriculum materials developed by an external organization or publisher in 2021–22, in addition to teaching CoolThink@JC. The publishers whose materials are most commonly used by CoolThink teachers (Silicon Workshop Limited/Dr.PC Family, Modern Educational Research Society Limited, A&I Education/Yiheng Education/New Generation of Digital Education) supply many out-of-network schools as well.

In-network and out-of-network school leaders have responded to different incentives in their curriculum adoption decisions.

Although EDB ICT curriculum guidelines are influential in both groups of schools, the opportunity to participate in CoolThink teacher professional development and the fit between CoolThink@JC and school goals are important drivers for network school leaders. In out-of-network schools, EDB policy is the most often cited driver of adoption decisions; more than 80% of out-of-network school leaders reported EDB policy was a primary consideration in their adoption decision.

Exhibit 17: Factors driving adoption decisions, CoolThink@JC vs. out-of-network school leaders



Source: Cohort 3 baseline school leader survey, 2019-20; Cohort 4 baseline school leader survey, 2020-21; Out-of-network school leader survey, 2019-20

In interviews, school leaders said they adopted CoolThink@JC for the opportunity to access professional development resources, to advance the school's STEM learning goals, and because they find CoolThink@JC to be more systematic and comprehensive than other ICT curricula. School leaders also reported considering teachers' and students' "pace of development" and their readiness to implement a new curriculum in making the decision to join the CoolThink network. One school leader also noted that CoolThink's successful pilot had promoted their decision to join the network:

> *We know about the team who are responsible for the [CoolThink] curriculum, and they are reputable individuals… Moreover, the first lot of schools have good feedback which includes students showing significant results and responses towards the curriculum.*
>
> – Principal

CoolThink@JC in the school-based curriculum

Network schools have made trade-offs in their schedules to adopt CoolThink@JC: most have chosen to integrate CoolThink lessons into other subjects, primarily ICT, and have reduced time spent on other ICT lessons to make more time for CoolThink@JC.

CoolThink curriculum materials are designed to be offered as a stand-alone course, with 35-minute lessons that can be offered in a single period of instruction or back-to-back in a double period. According to school leader report, about one-third of network schools (34%) teach CoolThink@JC as a stand-alone course in this way. Of these, half have dropped a different stand-alone course that required about the same amount of instructional time in order to fit CoolThink@JC into their school schedule, and the remainder have reduced the time allotted to other subjects or school activities or adopted creative approaches to scheduling, such as alternating CoolThink lessons with another subject on a biweekly basis.

About half of network schools (53%) teach CoolThink lessons integrated into their ICT classes and an additional 14% integrate CoolThink lessons into general studies or another subject. In interviews, school leaders described a variety of strategies for integrating CoolThink@JC into other courses. One said they combined course content from CoolThink@JC and the original EDB computer course, creating a school-exclusive textbook that highlighted CoolThink content that is "more trendy and modernized." One school leader described replacing the school's original computer lessons with CoolThink@JC; another said CoolThink@JC is taught as part of math and general studies and that they leave it to teachers to integrate in the ways they see fit. Another school leader said teachers would teach CoolThink@JC alongside software like MS Excel and MS Painter, as well as digital literacy.

Consistent with the teacher survey, two-thirds of school leaders (67%) reported their teachers spent more than the expected 14 hours on CoolThink instruction in 2021–22, even accounting for COVID-related disruptions to the school day. Among these schools, half (56%) reported they had planned the master schedule in advance in order to devote more than 14 hours to CoolThink lessons. In addition, half (50%) reported they made time by having students spend less time on other ICT lessons. Schools that offered CoolThink@JC as a stand-alone course were not any more likely to spend extra time on CoolThink@JC than schools that offered CoolThink lessons integrated into other subjects.

Developing teacher capacity

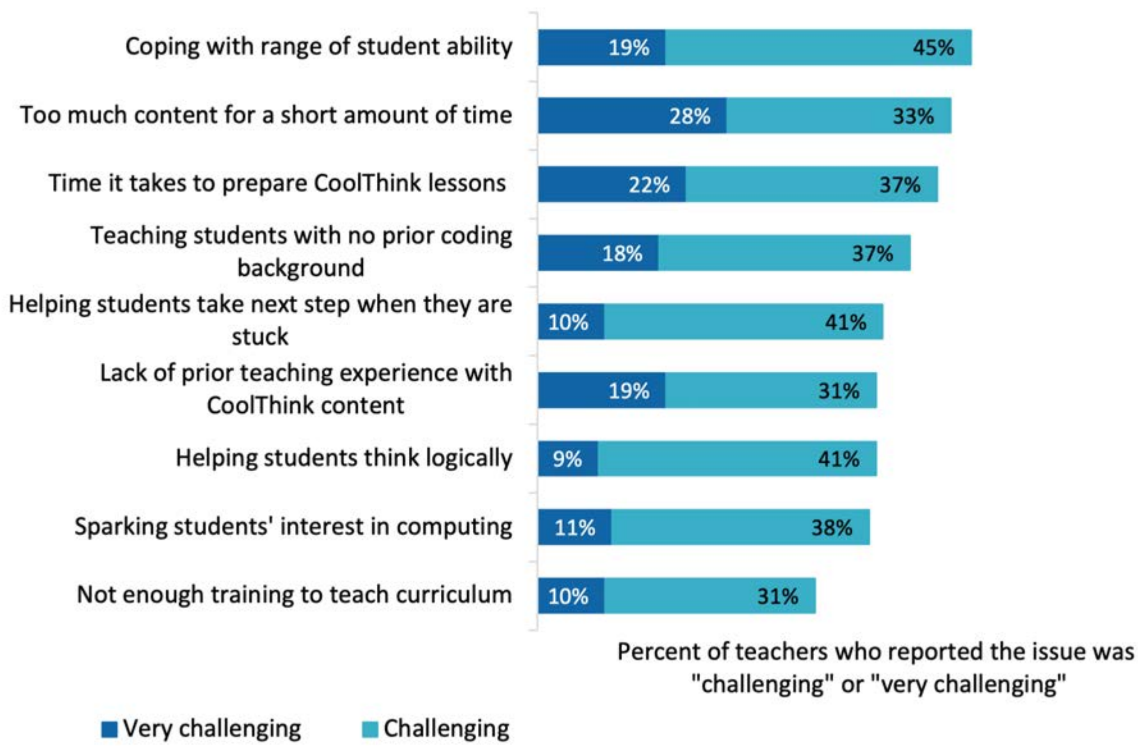
Teachers' capacity to deliver CoolThink lessons as designed—and with enough skill to ensure that all students develop deep conceptual understanding in addition to completing the tasks assigned—is critical to the success of CoolThink's scaling effort.

We hypothesize that schools that develop strong teacher capacity in the scaling phase are more likely to sustain CoolThink instruction in the long run; their students are also more likely to develop the computational thinking skills measured by CoolThink assessments.[3]

Teachers consistently reported that CoolThink@JC is a challenging curriculum to teach, although their confidence in teaching computational thinking has grown over time.

A large majority of CoolThink teachers reported multiple challenges when teaching CoolThink lessons, with no significant differences by cohort or experience level (first-year or second-year CoolThink teacher). Most CoolThink teachers reported the curriculum is "challenging" or "very challenging" to teach because of the range of student ability in their classrooms, the difficulty fitting all of the content into the available time, and the time it takes to prepare CoolThink lessons. Of these, about one 1 in 4 teachers said that the teaching so much content in a short amount of time was "very challenging."

Exhibit 18: Challenges teaching CoolThink curriculum



n = 500

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

[3] We will have the opportunity to test both of these hypotheses in the final year of the implementation study, leveraging student outcomes data and data from the spring 2023 survey of Cohort 1 and 2 teachers.

Teachers who were interviewed identified the same challenges as described above, noting they lacked time to cover all of the required content and to engage in CoolThink pedagogy as they had been trained to do:

> *With 7 [TPAK steps] and 4 teaching strategies to complete, it was difficult to cover them all due to time constraints... A CoolThink lesson is usually over 1 hour of content, but we only have 1 hour of STEM lessons. The time is a bit too tight. If we add more time, other courses would be tight. It is a bit of a struggle.*
>
> – CoolThink teacher

> *Also, the teaching curriculum is too tight, too packed, and too much. I have very limited time to teach, especially when lesson times are shortened due to COVID. I think quality in teaching is more important than quantity in teaching. We should cut some topics and let students have a chance to think and reflect.*
>
> – CoolThink teacher

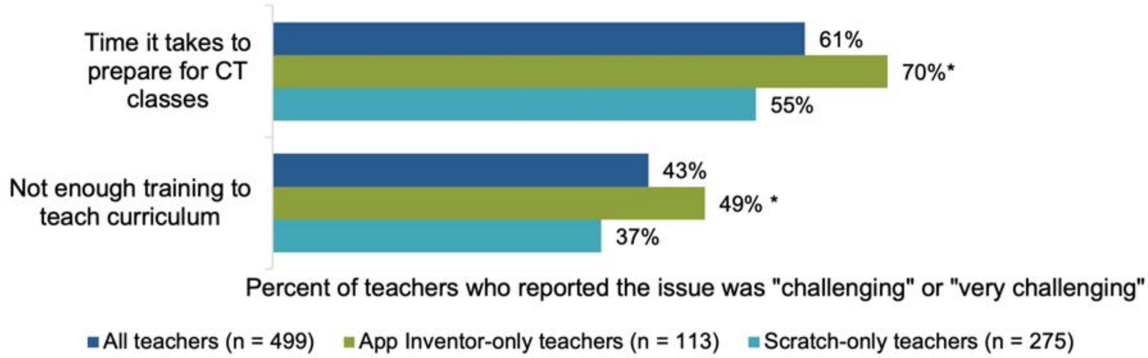
About half of teachers noted that their own lack of prior experience teaching coding and other CoolThink content was a challenge, as this teacher described:

> *The biggest challenge for me is that I have no ICT background nor coding foundation. If the students want to make some changes in the coding part, I cannot help with that, I cannot [help them] make an advanced upgrade in coding.*
>
> – CoolThink teacher

Level 2 and Level 3 (MIT App Inventor) teachers were more likely to say the CoolThink curriculum is challenging, in particular citing the time needed to prepare lessons and lack of adequate training.

CoolThink teachers assigned to App Inventor courses were slightly more likely to report that teaching CoolThink@JC was challenging in all respects, compared with teachers who taught Level 1 (Scratch; see appendix). The differences between Scratch and App Inventor teachers were largest with regard to preparation time and lack of training. This is consistent with our finding at baseline that CoolThink teachers were far more likely to have prior experience teaching with Scratch than with App Inventor. Given this, comprehensive teacher professional development may be especially important for teachers of Level 2 & 3 courses.

Exhibit 19: Challenges teaching CoolThink lessons, by teaching assignment

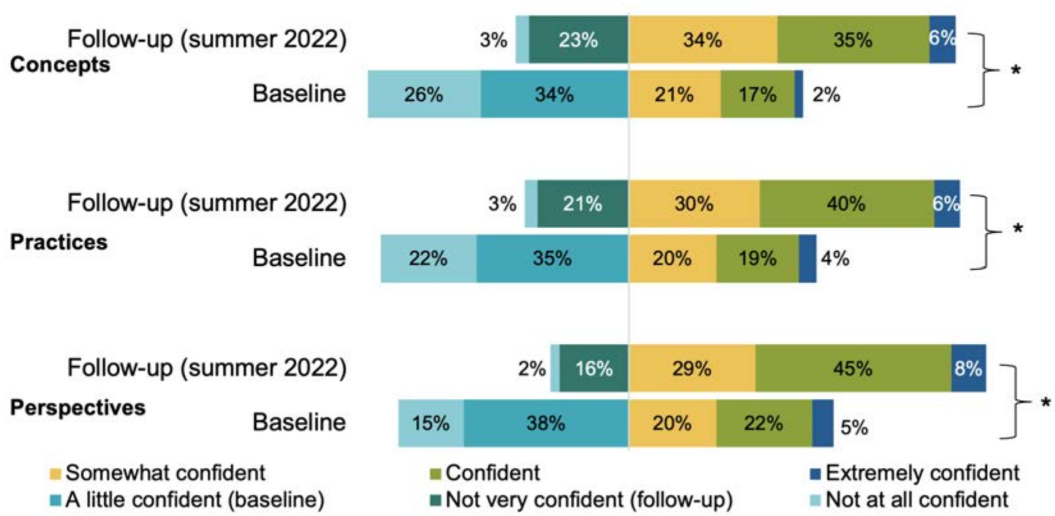


*~p<.10 *p < .05, **p <.01, applied to the difference between App Inventor-only and Scratch-only teachers*

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

Despite these challenges, teachers' confidence teaching computational thinking concepts, practices and perspectives increased with time (see Exhibit 20). After one year (cohort 4) or two years (cohort 3), teachers' confidence teaching computational thinking concepts, practices, and perspectives had increased significantly compared with baseline, especially among teachers who initially reported they were not at all confident with these topics. There were no significant differences in confidence levels between teachers in their second year of teaching CoolThink@JC and teachers in their first.

Exhibit 20: Teacher confidence incorporating computational thinking concepts, practices, and perspectives into their teaching



n = 353. Sample limited to teachers who responded both at baseline and at follow up.

*~p < .10, *p < .05, **p <.01. Differences between baseline and follow-up are statistically significant for the category including "somewhat confident," "confident," and "very confident."*

Note: The survey scale was changed for the 2022 follow-up survey: "A little confident" at baseline was replaced with "Not very confident" at follow-up.

Source: Cohort 3 baseline teacher survey; Cohort 4 baseline teacher survey; Cohorts 3 & 4 follow-up teacher survey (summer 2022)

Teacher Participation in Professional Development

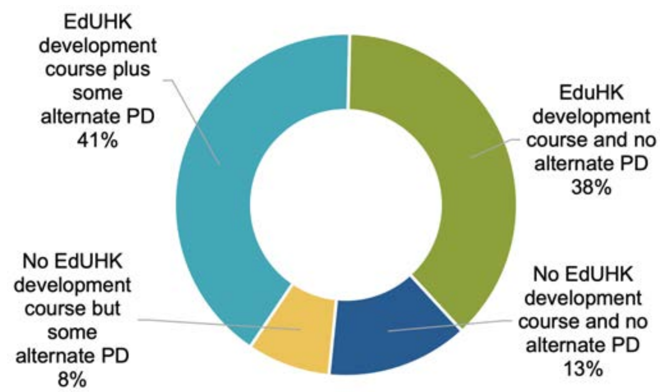
Teacher confidence incorporating CTE concepts, practices, and perspectives has increased over baseline in part because of their participation in CoolThink professional development, both the teacher development courses provided by EdUHK and the support provided by CoolThink mentor teachers.

CoolThink teacher development courses are the most prevalent source of training for CoolThink teachers.

The teacher development courses offered by EdUHK continued to be the most common source of professional development for in-network CoolThink teachers in the second year of CoolThink's scaling phase. In 2021–22, 393 out of 498 or 80% of CoolThink teachers across cohorts 3 and 4 took at least one teacher development course offered by EdUHK. Teachers in both cohorts completed courses on Understanding CTE and Scratch Programming (53%) and/or Understanding CTE and App Inventor Programming (54%) although Cohort 4 teachers received priority for enrollment in these courses and made up the vast majority of course-takers in 2021–22. About 10% of teachers completed the 2-hour supplemental tutorials for Scratch and App Inventor. About a quarter of teachers completed the course on Advanced App Inventor & AI Awareness, and 18% completed the course on Programming Robotics & School-based Curriculum Planning and Development.

For just over a third of teachers (38%), the CoolThink teacher development courses were their only source of professional development or coaching on computational thinking in 2021–22 (Exhibit 21). In total, about half of teachers (51%) reported they participated in at least one alternate form of teacher professional development in 2021–22 (for example, an EDB or InnoCommunity workshop). A large minority of CoolThink teachers (41%) combined a CoolThink teacher development course with some other form of teacher PD. For just over a third of teachers (38%), the CoolThink teacher development courses were their only source of professional development or coaching on computational thinking in 2021–22. A small number of teachers (13%) reported they did not participate in any form of professional development in 2021–22.

Exhibit 21: CoolThink teacher participation in professional development on computational thinking education, 2021–22



n = 484

Note: Includes both Cohort 3 and Cohort 4 teachers. Alternative forms of PD included EDB and InnoCommunity workshops on computational thinking, and coaching from more experienced school-based CoolThink teachers or mentor teachers

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

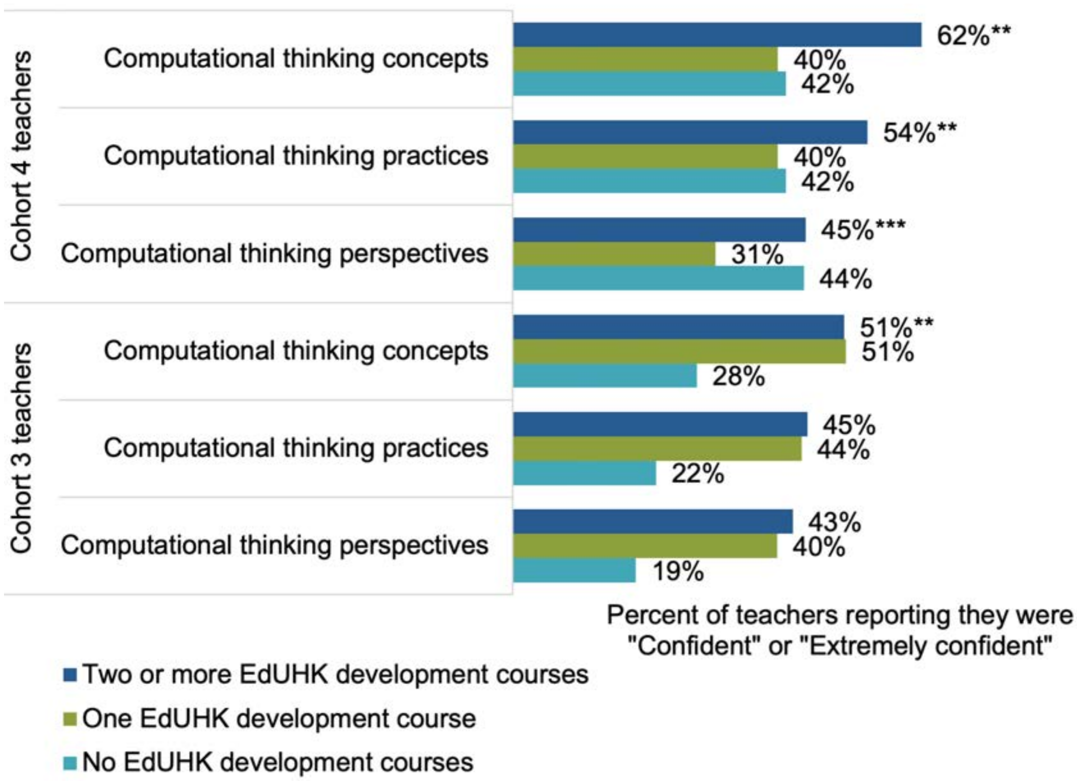
CoolThink teachers who completed teacher development courses in 2021–22 reported greater levels of confidence teaching CTE than teachers who did not. Among cohort 4 teachers who were taking development courses for the first time, those who completed two or more courses (accounting

for 24 or more hours of training) reported greater levels of confidence that teachers who completed only one or none.

Cohort 4 teachers received priority for enrollment in EdUHK development courses in 2021–22 because it was their first year teaching CoolThink@JC. Among these teachers, more than two-thirds (68%) completed two or more courses, and these teachers were more likely to report that they were "Confident" or "Extremely confident" incorporating computational thinking concepts and practices into their instruction (Exhibit 22). The spring 2022 surveys asked only about CoolThink teacher development courses completed during the 2021–22 school year, and so do not account for the courses completed by cohort 3 teachers in 2020–21, when they had priority for enrollment. However, those cohort 3 teachers who had the opportunity to complete one or more development courses in 2021–22 (in addition to any that they had completed the previous year) were much more likely to report feeling confident about their instruction related to computational thinking.

Teacher reports of the challenges they faced in teaching CoolThink were not related to the number of development courses completed.

Exhibit 22: CoolThink teacher confidence, by number of development courses completed in 2021–22



Cohort 4 two or more EdUHK development courses n = 170; Cohort 4 one EdUHK development course n = 42; cohort 4 no EdUHK development courses n = 36; cohort 3 two or more EdUHK development courses n = 89; Cohort 3 one EdUHK development course n = 59; cohort 3 no EdUHK development courses n = 96.

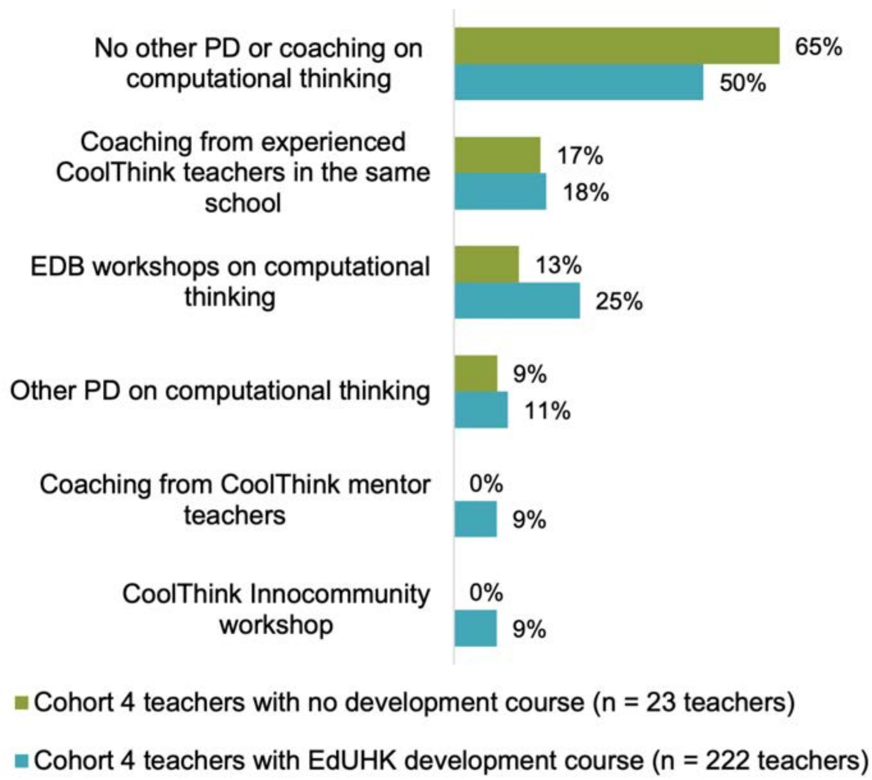
*~p < .10, *p < .05, **p <.01.*

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

About half of CoolThink teachers participated in some alternate source of professional development 2021–22, but CoolThink teachers did not participate in any one of these alternative sources of professional development in large numbers.

Teacher participation in each individual form of alternative professional development was relatively low, with fewer than 25% of teachers participating in each of these offerings, and it does not appear that these alternate sources of PD were serving as substitutes for the courses offered by EdUHK. In the case of Cohort 4 teachers, for example, only teachers who had taken a development course in 2021–22 received coaching from mentor teachers or took an InnoCommunity workshop as well. The small number of Cohort 4 teachers who were not able to take a teacher development course with EdUHK did not participate in other forms of teacher PD at higher rates than their peers (Exhibit 22).

Exhibit 23: Cohort 4 teacher participation in alternate professional development on computational thinking in 2021-22



Note: Sample limited to Cohort 4 teachers because Cohort 3 teachers may have taken a EdUHK teacher development course before 2021–22 and so could not be assigned with certainty to the subgroups represented in the exhibit.

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

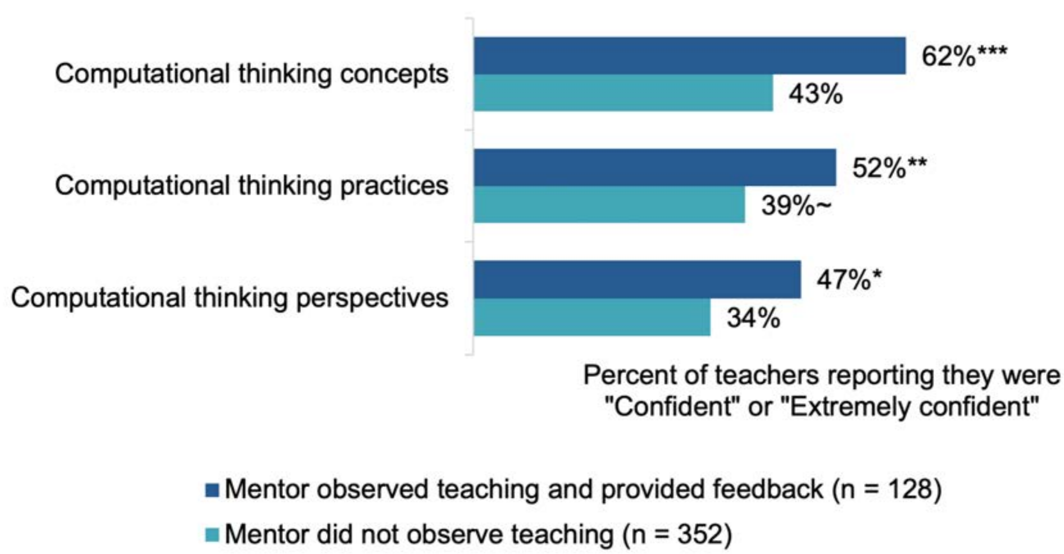
CoolThink teachers who had the opportunity to work with a CoolThink mentor teacher, especially those who had been observed by a mentor teacher and received feedback on their instruction, reported higher levels of confidence than teachers who did not.

CoolThink mentor teachers have developed exceptional skills and interest in CoolThink@JC over the years and have attended additional trainings above and beyond that required, such as participating in MIT's Master Training Course. Mentor teachers serve as coaches and trainers for other teachers trying to learn about CoolThink@JC; they work at resource schools that serve as exemplars for other teachers to learn from. As teachers who started in earlier cohorts of CoolThink@JC, these teachers serve as role models to others and share lessons they themselves have learned along the way.

About two-thirds of CoolThink teachers (68%) teachers reported interacting with a CoolThink mentor teacher at least once during the 2021-2022 school year. Most teachers (53%) reported 1–5 interactions during the school year; interactions typically happened in a group setting or via a WhatsApp group (and so would not be identified as "coaching" as in the exhibit above). One common mode of interaction (reported by 40% of those who interacted with mentor teachers) included receiving feedback on their teaching from a mentor teacher.

The two-thirds of CoolThink teachers who had interacted with a mentor teacher in 2021–22 reported higher levels of confidence teaching computational thinking than those who did not. The difference was especially marked for the 40% of teachers who were observed by a mentor and received feedback on their instruction (Exhibit 24). It was also significant for the relatively small number of teachers who met with their mentor to plan a CoolThink lesson. Interactions with a mentor teacher were not related to teachers' perceptions of the challenge teaching the CoolThink curriculum.

Exhibit 24: CoolThink teacher confidence, by interaction with mentor teachers in 2021–22



Within CoolThink schools, about two-thirds of CoolThink teachers (65%) met with other CoolThink teachers to collaborate, plan, and/or discuss CoolThink instruction. When teachers interacted with other fellow CoolThink teachers, they focused primarily on discussing CoolThink curricular materials and pedagogical strategies and planning CoolThink lessons. Most interviewed teachers said they met regularly with other teachers to discuss CoolThink@JC and that they participated in a WhatsApp group of CoolThink teachers. Discussions on WhatsApp focused primarily on technical issues; a few teachers also said they shared information and resources on the app. Within schools, about 1 in 5 teachers reported their CoolThink lead teacher, other senior CoolThink teachers, or their ICT or STEM lead teacher was an important source of support for helping them become proficient CoolThink teachers (noting this had supported them to a great extent), and about half reported they had received at least moderate support from these roles.

Teacher membership in school-based CoolThink teams was not related to their level of confidence in teaching computational thinking or their perceptions of the challenges related to using the CoolThink curriculum.

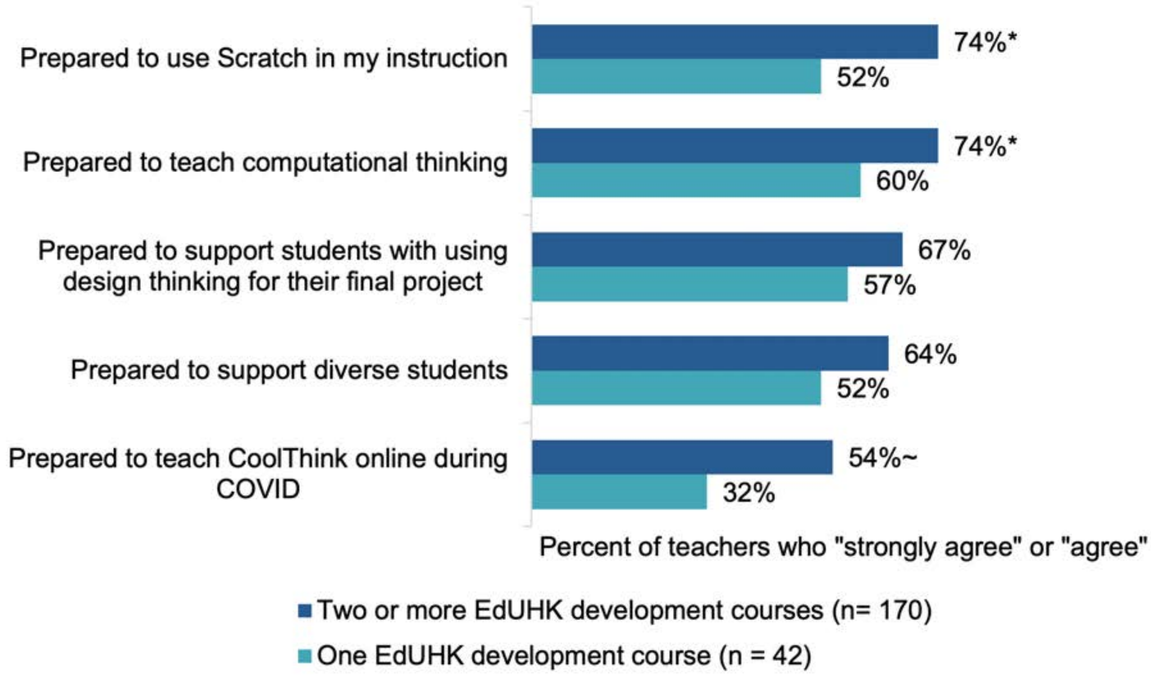
Teacher readiness to teach CoolThink@JC

Although most CoolThink teachers agreed they felt prepared to teach computational thinking, CoolThink lesson content, and use the Scratch programming language as part of their instruction, fewer teachers reported feeling prepared to use App Inventor (56%), teach CoolThink online during COVID restrictions (57%), and support the needs of diverse students (64%). Teachers' self-reports of their readiness to teach CoolThink@JC did not vary by cohort, experience (first-year or second-year CoolThink teacher) or teaching assignment (Scratch vs. App Inventor), although among Cohort 4 teachers they did vary by the number of courses completed.

Cohort 4 teachers who competed two teacher development courses (24 hours of training) felt better prepared to teach CoolThink than teachers who completed only one (12 hours of training).

Teachers who completed at least one CoolThink teacher development course generally agreed they learned new things from the courses that they were not previously aware of, and consistently reported they felt better prepared to teach CoolThink@JC. Cohort 4 teachers who completed two or more courses generally felt better prepared than teachers who completed only one, especially with regard to using Scratch in their instruction, teaching computational thinking, and teaching online (Exhibit 25). (Teachers who did not complete any development courses were not asked a follow-up question about their readiness and so are not included in this analysis.) The same pattern does not hold for Cohort 3 teachers, many of whom completed the level 1 and level 2 courses in 2020–21. The more advanced courses that many cohort 3 teachers completed in 2021–22 do not appear to have the same effect on teachers' perceptions of their readiness.

Exhibit 25: Teacher self-reports of readiness to teach CoolThink@JC, by number of teacher development courses completed



*~p < .10, *p < .05, **p <.01.*

Note: Sample limited to cohort 4 teachers who completed at least one teacher development course. Teachers who did not complete development course(s) were not asked a follow-up question about how well the course(s) had prepared them to teach CoolThink@JC and so are not represented in this exhibit.

Source: Cohorts 3 & 4 follow-up teacher survey (summer 2022)

These survey findings were corroborated in teacher interviews, with most teachers confirming that the teacher development courses helped prepare them to teach CoolThink@JC. The interviews also revealed that teachers found the App Inventor training and the fast pace of the courses to be among some of the least helpful aspects of the development courses. Teachers who said the App Inventor training was not helpful said it was because the trainer just told them to follow steps (two teachers used the phrase “spoon-fed”), it was too fast-paced, and because they didn’t have opportunities to engage and to ask questions. Not surprisingly, Level 2 and Level 3 (App Inventor) teachers consistently reported they found various aspects of CoolThink instruction more challenging than Level 1 (Scratch) teachers, as described above.

School capacity to adopt and sustain CoolThink@JC

Schools that have extensive prior experience with ICT instruction may find the adoption of CoolThink materials to be a lighter lift than those attempting ICT instruction for the first time. In addition, school leader beliefs about the value of ICT instruction, both teachers’ and the school leader’s willingness to take risks in trying something new, curriculum policy and guidance from supervising bodies, and student and parent interest are all important indicators of school capacity to adopt CoolThink@JC.[4]

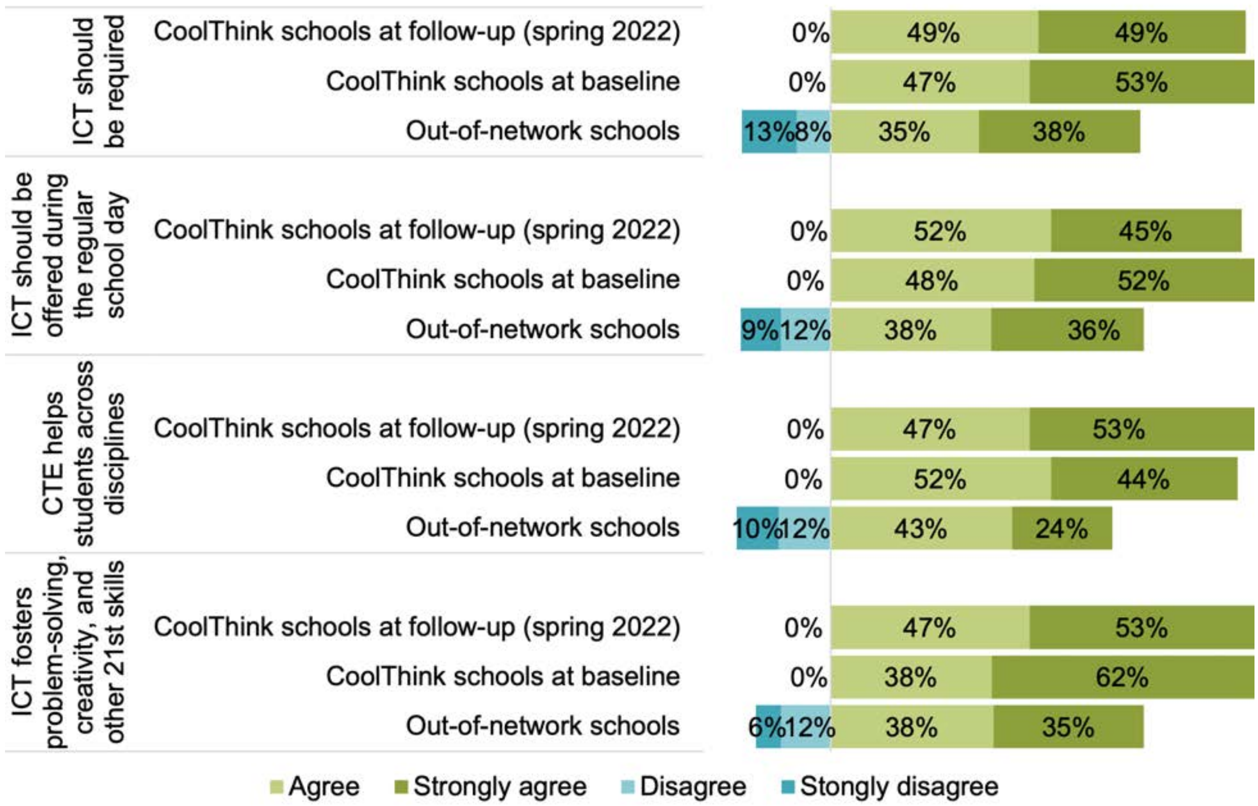
As early adopters, Cohort 3 and 4 schools demonstrated higher levels of readiness to take up CoolThink@JC at baseline, compared with other Hong Kong primary schools. In-network schools' readiness increased over time, as they gained experience with CoolThink@JC.

Indicators of readiness to adopt and sustain CoolThink@JC included school leaders' investment in ICT instruction and support for innovation, access to resources to support ICT instruction (both material resources and stakeholders' knowledge and interest), and external policies and guidance governing curriculum adoption, as described below.
School leader beliefs about the value of CTE and support for innovation

Every surveyed CoolThink school leader agreed with statements about the importance of mandatory, in-school ICT instruction and its benefits for developing problem-solving and other 21st-century skills (Exhibit 26). These beliefs—already high at baseline—did not change as schools gained experience with CoolThink@JC. Beliefs about the value of ICT instruction were not as widely shared in out-of-network schools. For example, even though 87% of out-of-network primary schools offered ICT lessons during the regular school day (see Exhibit 16 above), more than 20% of school leaders disagreed with the proposition that ICT should be a required subject at the primary level or that it should be offered during the regular school day. Similarly, out-of-network school leaders were less likely than in-network school leaders to believe that ICT fosters creativity, problem-solving, and other 21st-century skills, or that CTE can benefit students across disciplines.

[4] We will have the opportunity to test these hypotheses in the final year of the implementation study, leveraging data from the spring 2023 survey of Cohort 1 and 2 teachers.

Exhibit 26: School leader beliefs about the importance of ICT and computational thinking education, CoolThink and out-of-network schools



Out-of-network schools n = 203; CoolThink schools at baseline n = 69; CoolThink schools at follow up (spring 2022) = 69. Sample limited to CoolThink schools that responded both at baseline and at follow up.

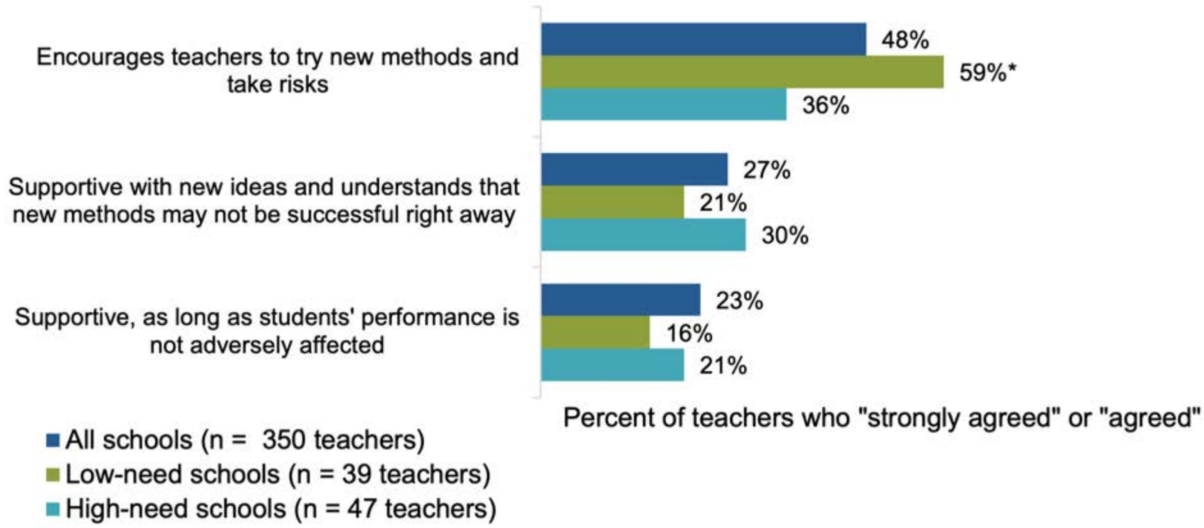
Note: Schools that neither agreed nor disagreed not shown, so rows do not sum to 100%.

Differences between out-of-network schools and CoolThink schools at baseline are statistically significant for the category of schools that agreed or strongly agreed.

Source: Cohort 3 baseline school leader survey, 2019-20 C4 baseline school leader survey, 2020-21, and out-of-network school leader survey 2019-20

At baseline, about half of teachers (48%) reported their school leader encouraged them to try new methods and take risks, without voicing concerns about possible impacts on student performance (Exhibit 27). Among high-need schools, school leaders' support for innovation was more likely to come with a qualification: teachers in high-need schools were more likely to report their school leader supported innovation as long as students' performance was not adversely affected, or that they supported innovation even though they understood that the new methods might not be successful right away.

Exhibit 27: School leader support for innovation, by school financial aid



*~p < .10, *p < .05, **p <.01, applied to differences between low-need and high-need schools*

Note: Sample limited to spring 2022 teachers who also responded to the baseline survey.

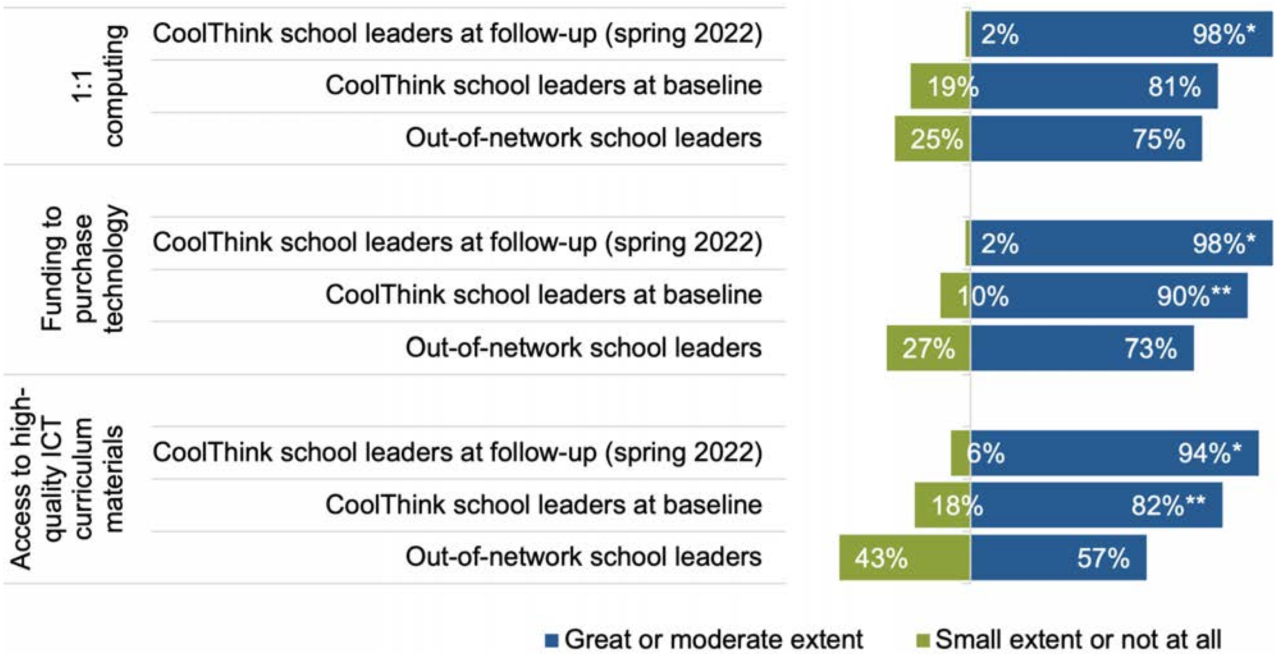
Source: Cohort 3 baseline teacher survey, 2019–20 C4 baseline teacher survey, 2020–21

Resources supporting strong ICT instruction

At baseline, CoolThink school leaders were also more likely than those at out-of-network schools to report their school had access to the material resources needed for ICT instruction, including access to high-quality curriculum materials, enough computers or laptops to support 1:1 computing during ICT lessons, and funding to purchase additional technology if needed (Exhibit 28).

In addition, CoolThink school leaders were more likely to report that teachers' knowledge and willingness to experiment, student interest, and parent support were important factors supporting ICT instruction at baseline. As their schools gained experience with CoolThink@JC, the proportion of school leaders reporting these resources for strong CoolThink instruction in their schools increased.

Exhibit 28: Resources supporting strong ICT instruction, CoolThink and out-of-network schools

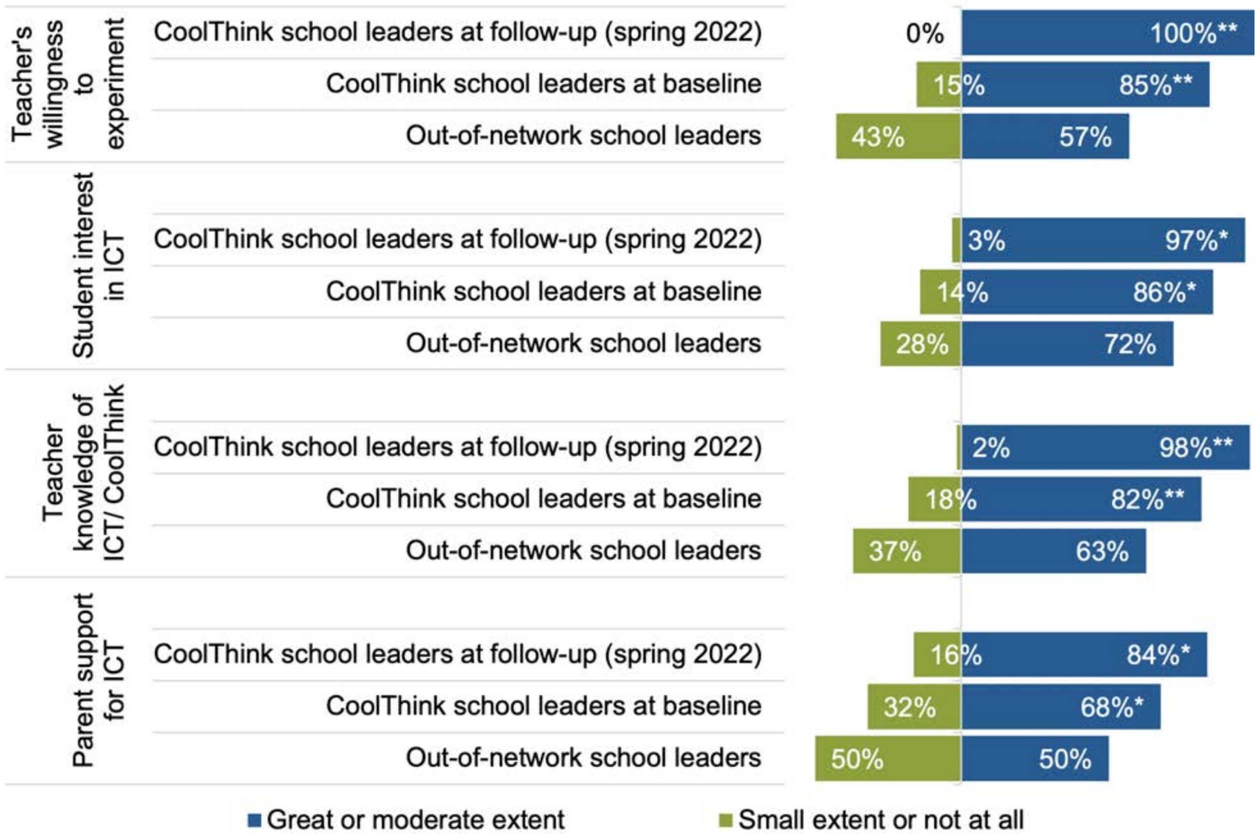


Out-of-network schools n = 159; CoolThink schools at baseline n = 72; CoolThink schools at follow up (spring 2022) = 64.

**p < .05, **p <.01, applied to the difference between CoolThink school leaders at follow-up and CoolThink school leaders at baseline, and to the different between CoolThink school leaders at baseline and out-of-network school leaders.*

Source: Cohort 3 baseline school leader survey, 2019-20 C4 baseline school leader survey, 2020-21, and out-of-network school leader survey 2019-20

Exhibit 29: Knowledge, interest, and support for ICT and CoolThink instruction



Out-of-network schools n = 159; CoolThink schools at baseline n = 72; CoolThink schools at follow up (spring 2022) = 64.

**p < .05, **p <.01, applied to the difference between CoolThink school leaders at follow-up and CoolThink school leaders at baseline, and to the different between CoolThink school leaders at baseline and out-of-network school leaders.*

Source: Cohort 3 baseline school leader survey, 2019-20 C4 baseline school leader survey, 2020-21, and out-of-network school leader survey 2019-20

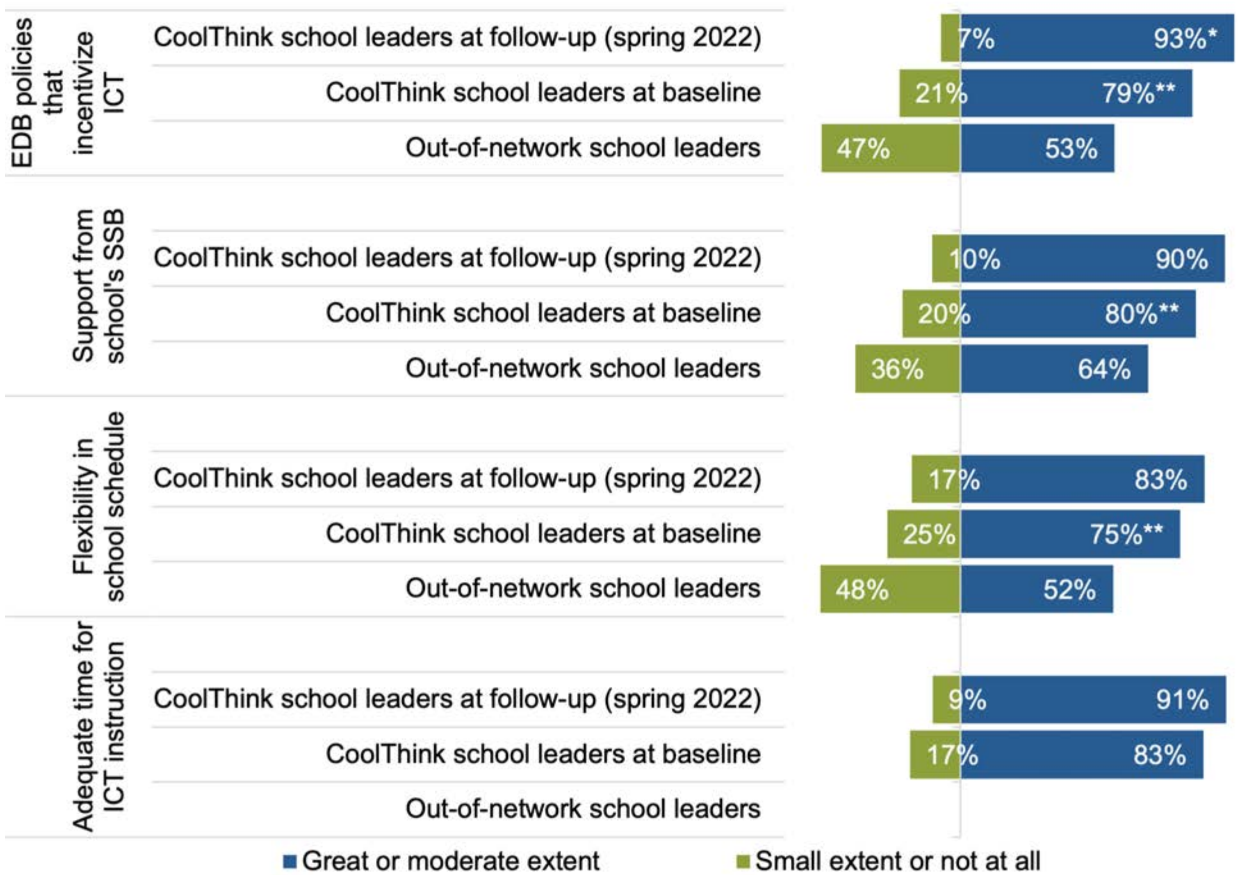
Curriculum policy and guidance from supervising bodies

Instructional time is a finite resource, and many subjects in the primary school curriculum must be accommodated within the limits of the existing school day. Both in-network and out-of-network school leaders cited EDB curriculum guidance as a primary factor influencing their adoption decisions. Along with EDB policy, support from school sponsoring bodies, and within-school factors that guide the allocation of instructional time can all contribute to school capacity to adopt and sustain CoolThink@JC.

Although EDB policy applies in the same way to all Hong Kong primary schools, CoolThink school leaders were more likely to say it was an important resource that supports strong ICT instruction , and this difference has widened over time as schools gained experience with CoolThink@JC (this may be because they see CoolThink@JC is well-aligned with EDB policy). Notably, despite the fact that most out-of-network school leaders reported they considered EDB's ICT curriculum guidelines when making adoption decisions (see Exhibit 17), almost half reported EDB policies in 2019–20 incentivized strong

ICT instruction to a small extent or not at all (Exhibit 30). Although out-of-network leaders clearly consider EDB guidance when deciding what curriculum to use, they don't believe EDB policy incentivizes or supports the implementation of that curriculum.

Exhibit 30: Existing policies and guidance supporting strong ICT instruction



Out-of-network schools n = 159; CoolThink schools at baseline n = 72; CoolThink schools at follow up (spring 2022) = 64.

Note: The survey item addressing adequate time for ICT instruction was not presented to cohort 3 or out-of-network schools. The frequencies shown represent cohort 4 schools only.

**p < .05, **p <.01, applied to the difference between CoolThink school leaders at follow-up and CoolThink school leaders at baseline, and to the different between CoolThink school leaders at baseline and out-of-network school leaders.*

Source: Cohort 3 baseline school leader survey, 2019-20 C4 baseline school leader survey, 2020-21, and out-of-network school leader survey 2019-20

Differences between in-network and out-of-network schools are smaller, but the overall trend is the same for other kinds of external and internal policies. For example, 48% of out-of-network school leaders reported limited flexibility in their school schedules, compared with just 17% of network schools at follow-up, after they had launched CoolThink@JC.

DEVELOPMENT OF A COOLTHINK ECOSYSTEM

A key long-term goal for CoolThink@JC is the development of a sustainable, territory-wide ecosystem to support computational thinking education (CTE). To understand progress towards developing this ecosystem, we examined the CoolThink governing structure, interviewed systems-level actors involved in CoolThink@JC and CTE across a range of organizations, and reviewed relevant data from the school leader follow-up survey. It is important to recognize that the 11 system-level stakeholders interviewed in 2022 were all members of the CoolThink governance structure in some way, so these data look at accomplishments and goals from within the developing ecosystem. The fact that this group still represents a broad range of participants in important CTE-related efforts in Hong Kong attests to the breadth and strength of the coalition that CoolThink@JC has assembled to date.

CoolThink Governance Structure

CoolThink@JC is supported by an extensive network that is inclusive of organizations from across the CTE system. As the initiative's backbone organization, The Trust's Central Coordination Team (CCT) plays a key role in convening partners and executing project activities.

CoolThink@JC's organizational structure includes a Steering Committee; an Expert Group; three subcommittees to promote School Adoption & Sector Capacity-Building, Public Awareness and Support, and Tools and Intellectual Leadership and Platform Building; as well as a Consultative Group. As CoolThink@JC's backbone organization, The Trust's CCT is engaged in all facets of the governance structure and is responsible for stakeholder engagement, partnership development and management, InnoCommunity network building, community and NGOs outreach, and public education and awareness building.

Participants in CoolThink's governance structure represent both entire organizations championing CoolThink@JC through organization-level activities as well as individuals. The CoolThink governing structure includes members from government, industry, NGOs, non-profit organizations, and schools and universities. Exhibit 29 describes the members in each of these governing bodies, arranged by organization type.

Exhibit 31: Organizations represented in CoolThink's governing structure subcommittees

	Steering Committee	Expert Group	Subcom. A: School Adoption & Sector Capacity-Building	Subcom. B: Public Awareness and Support	Subcom. C: Tools and Intellectual Leadership and Platform Building	Consultative Group
Organizations Championing CoolThink@JC						
Convener / backbone organization						
The Hong Kong Jockey Club Charities Trust	X	X	X	X	X	X
Government agencies / affiliates						
Hong Kong Education Bureau	X	X				
Hong Kong Education City Limited (EdCity)						X
Teachers' associations						
Association of I.T. Leaders in Education (AiTLE)		X		X		X
Hong Kong Association for Computer Education (HKACE)		X		X		X
School sponsoring bodies (SSBs)						
Catholic Diocese of Hong Kong						X
Po Leung Kuk						X
Tung Wah Group of Hospitals						X
Universities						
City University of Hong Kong	X	X	X	X	X	
MIT		X	X	X	X	
MIT Hong Kong Innovation Node	X					
The Education University of Hong Kong (EdUHK)	X	X	X	X	X	

	Steering Committee	Expert Group	Subcom. A: School Adoption & Sector Capacity-Building	Subcom. B: Public Awareness and Support	Subcom. C: Tools and Intellectual Leadership and Platform Building	Consultative Group
Individuals Championing CoolThink@JC						
Industry leaders						
Esquel Group	X					
Microsoft Hong Kong Limited	X					
Primary school leaders						
Chan Sui Ki (La Salle) Primary School		X				
Fung Kai No. 1 Primary School		X				
King's College Old Boys' Association Primary School No. 2		X				
PLK Dr Jimmy Wong Chi-Ho (Tin Sum Valley) Primary School						X
St. Edward's Catholic Primary School						X
The Education University of Hong Kong Jockey Club Primary School		X				
Heads of professional organizations						
Hong Kong Aided Primary School Heads Association	X					

Note: Exhibit displays organizations represented in the CoolThink governing structure. Panel A displays organizations that serve as champions of CoolThink@JC throughout the organization. Panel B displays organizations that have individual members who participate in CoolThink's governance and are champions of CoolThink@JC. Data retrieved from CoolThink's web description of their governing body members as of February 2023: https://www.coolthink.hk/en/about-us/who-we-are/. In addition to the members listed on the website, several other organizations serve as champions of CoolThink@JC such as The University of Hong Kong (HKU), the Chinese University of Hong Kong, Hong Kong Sheng Kung Hui (SKH), and Hong Kong Academy for Gifted Education, among others.

As Exhibit 31 shows, CoolThink's governing structure has representation from a diverse range of interests and perspectives from across the CTE space. This ensures that multiple perspectives and voices are included in decision-making, materials are shared across stakeholders, and information about CoolThink@JC is disseminated across the CTE ecosystem. The structure is also highly interconnected, with several organizations represented on some of the governing bodies. Through their participation on multiple aspects of CoolThink's governing structure, representatives from these organizations have access to a systems-level view of CoolThink's adoption across the territory and are well-positioned to advocate for CoolThink@JC, considering not only its overall adoption, but also resources for program support and tools and materials for its implementation.

Across organizations, key system-level actors articulated strong support for CoolThink's mission and the importance of computational thinking in developing problem-solving and other 21st century skills.

Respondents had deep knowledge of the CoolThink initiative and its history, goals, and progress to date, and appeared to be strongly invested in CoolThink's success. They recognized the critical importance of the CoolThink school network as a strong starting point and exemplar for the developing ecosystem and argued that teachers are demonstrating success in teaching coding, learning with students, and implementing enriching and engaging activities with students: success that can be inspiring to other teachers and schools. They noted that one of the primary contributions of CoolThink@JC is the opportunity to standardize the primary school ICT curriculum.

That is very amazing when you can see the student can use their creativity and the problem-solving skills to improve [the] solution.

– System-level actor

Systems-level supports for CoolThink@JC and CTE

Although systems-level observers believe the ecosystem is still developing, they emphasized that CoolThink@JC has been a key driver of innovation to improve teachers' professional preparation and encourage CTE adoption.

The CoolThink ecosystem includes multiple mechanisms to support teachers' implementation of CoolThink@JC and of broader computational thinking education. For example, EDB now collaborates with InnoCommunity teachers, the MIT Innovation Node, and AiTLE to provide professional development on CoolThink@JC and CTE; this is a professional development opportunity that supports efforts to scale CoolThink@JC to other teachers who may not otherwise have access to the CoolThink materials. Broad collaborations that include CoolThink developers can help to communicate CoolThink's goals and pedagogy as well as the details of its lessons.

Pedagogy is the thing that we treasure. We do not want students to just focus on the outcome, but we have to focus on the process of breaking down problems, analyzing problems, how to find a way to improve the solutions and how to collaborate with their peers... That is the process that we have to focus on.

– System-level actor

Programmatic elements of the ecosystem continue to expand rapidly. Elements that respondents perceive as important include, but are not limited to:

- CoolThink's InnoCommunity and resource school/mentor teacher networks, which provide access to expertise and exemplars from experienced CoolThink educators. New CoolThink teachers can access these mentors through a series of professional development offerings from InnoCommunity and EDB, and this corpus of expertise could continue to expand to provide coaching to teachers outside the current network.
- University-based supports for teachers and teacher candidates are important and growing. For example, both EdUHK and HKU are increasingly integrating computational thinking into their undergraduate curricula as part of teacher preparation, and CityU has trained hundreds of university students to assist teachers with CoolThink implementation in their classrooms.
- CoolThink-sponsored competitions are recognized as an important way to expand momentum, excitement, and visibility of computational thinking among students and parents. Booths in other fairs and community gatherings also spotlight computational thinking to the public.
- School sponsoring bodies are an additional mechanism for spreading information about CTE among schools in their own networks.
- Respondents also cited growing awareness of and support for CoolThink@JC through workshops and other outreach efforts by CityU and other organizations.

Vision and challenges for scaling CoolThink@JC in Hong Kong

System-level actors' goals for the future of CoolThink@JC included scaling to secondary schools and integrating CTE across different subject areas.

Systems-level actors emphasized the importance of scaling CoolThink@JC and other CTE efforts to secondary schools and even universities. In their view, prioritizing topics in upper levels will equip students with problem-solving skills that will help them find success in their academic and professional life, as well as promoting CTE as a priority in primary grades. To achieve this, systems-level actors suggested aligning the primary and secondary curricula and creating trainings for secondary teachers.

While a number of efforts are already underway to integrate CTE and AI into secondary curricula in Hong Kong, including pilot adoptions of CoolThink@JC, interviewees noted that professional development needs for secondary school ICT teachers may be different than primary, in particular because some teachers may come from stronger technology backgrounds. As a result, training would need to focus more on pedagogical practices rather than the fundamentals of coding and computational thinking. One challenge in scaling to secondary schools is multiple existing computer classes with widely varying curricula; therefore, some degree of standardization of goals is a necessary starting point.

Systems-level actors also argued that there is a need to "authentic[ally]" integrate computational thinking education into a range subjects like "oxygen" rather than treating CTE as a separate skill. They described wanting CTE to be thought of as a skill that can be applied to many contexts or learning experiences and not just a "coding" subject.

> *We not only necessarily focus on the academics, we need to understand how to build the skill for the student that they really can use in the future.*
>
> – System-level actor

> *What we are looking for is not a hundred percent of students becoming a programmer, but through the programming and coding education, we can build up the computational thinking and that is our ultimate goal, not the coding itself.*
>
> – System-level actor

Some systems-level actors believed that scaling CoolThink@JC to the remaining primary schools in Hong Kong will be easy because they believe the remaining schools will not want to "miss the bus" on participating in CoolThink@JC. Other actors we interviewed thought it would take time to scale to other schools because years of training and resources may be needed to change people's mindsets and pedagogical approaches.

Challenges to scale and sustainability include cost, uncertainty about where CTE fits into curriculum, teacher turnover, and a possible lack of leadership once The Trust scales back its role in leading scaling efforts.

Given that full-time staff members' work on CoolThink@JC and funding and materials are integral to successful program implementation, systems-level actors wondered whether and how these resources would be available in the future to support program implementation. They also expressed concern that schools and teachers may not know whether and how CTE fits into their curriculum, and subsequently, into their lesson-planning priorities. Many respondents highlighted that teacher turnover—and therefore, the continued need for teacher training—will remain a persistent challenge for program sustainability. Several systems-level actors were also curious about which organizations would step in to lead the initiative in the future.

One interviewee also emphasized the importance of teachers taking ownership over the design of materials to create tailored lessons for their students—a step they viewed as indicative of greater understanding and ownership over the pedagogy.

Sometimes, I saw that teachers rely on the ready-made materials.... People like the instant noodles, because it's quite quick. In just three minutes, you can fill up your tummy and get the thing done. But we want to inspire them. The ready-made materials can help you to step in... [but teachers need to build on these resources] to tailor-make to your group of students, so that the effectiveness can be unleashed more. It's not healthy to only rely on only one source of resources."

– System-level actor

To support continued scaling of CoolThink@JC, respondents highlighted the importance of EDB curriculum policy, identifying an organization to continue leading the CoolThink work, maintaining use of teacher-led communities of practice, and increasing parental outreach.

Respondents recognize the critical importance of the role EDB is increasingly taking to codify CTE education into the curriculum so that schools will be incentivized to teach it. They also suggested identifying or creating an organization to continue to lead and organize CoolThink activities. Without an organization with a clear vision at the helm, respondents are worried that CoolThink@JC will not be effectively sustained.

Many systems-level actors suggested maintaining and expanding use of teacher-led professional organizations, believing teacher-to-teacher professional development to be highly effective. These organizations can maintain CoolThink activities, events, and communities of practice.

Teachers talk about practices to their fellow colleagues, and that's the reality. So, good practices from fellow colleagues are more effective and if he or she can do it, so can I, and it can be done in my school. So, we make use of these characteristics from our teachers.

– System-level actor

Numerous respondents also suggested increased outreach to parents, citing parental support as a key factor in scale and sustainability. Outreach would both help parents understand the importance of CTE education and also increase parental demand for CTE education, which would incentivize schools to teach it.

CoolThink's Contribution to the CTE Ecosystem

Overall, system leaders believe CoolThink@JC has played a key role in driving innovation and structural change. Systems-level actors view CoolThink's key contribution to the ecosystem as a program that is leading innovation, driving important structural changes, and preparing large numbers of teachers' professional and pedagogical skills. In its role as backbone organization, CoolThink's CCT has successfully achieved several important milestones toward developing a self-sustaining CTE ecosystem for Hong Kong primary schools. These milestones include:

- Government adoption and adaptation of CoolThink learning materials to all primary schools in Hong Kong
- CoolThink adoption in more than 200 network primary schools

- CoolThink workshops and dissemination of materials to more than 85% of publicly funded primary schools
- Creative commons licensing permitting use of CoolThink materials by all educators in Hong Kong and the world
- Adoption of CoolThink's learning and training materials in the Education Bureau's formal regular teacher professional development course
- A partnership agreement with EdCity (signed December 2022) under which EdCity will host CoolThink materials on its platform, making them accessible to schools after the scaling period has ended
- Partnerships with teachers associations (AiTLE and HKACE) to expand and sustain the CTE teacher network and CoolThink InnoCommunity
- Global recognition and certification of CoolThink's curriculum and learning materials, promoting public awareness and signaling the quality of materials (e.g., recipient of the QS Reimagine Education Award, inclusion in the HundrED.org Global Collection, recipient of ISTE Seal of Alignment, certification by Education Alliance Finland)

System-level observers also recognized that the ecosystem is still developing—while the pieces are there, they are not sufficiently connected.

> *I see this as a disconnected ecosystem right now in different communities and whether these can be connected into the wider system as a larger network, I think we are still emerging and we are still working on it.*
>
> – System-level actor

To better connect groups and organizations in the CTE ecosystem, some systems-level actors suggested that representatives from all levels of the school-to-career pipeline should be involved in boosting CTE education, as groups from across the primary, secondary, and tertiary education system play an integral part in the larger CTE ecosystem. They identified points to better connect disparate efforts such as aligning primary, secondary, and university learning goals around CTE and engaging in corresponding teacher training.

RECOMMENDATIONS FOR CONTINUED SCALING OF COOLTHINK@JC

Data emerging from this study suggest a number of factors that we expect to be essential to the continued success of CoolThink@JC at scale, and more broadly to computational thinking education. The research will continue to test these factors as the adoption of CoolThink@JC in network schools continues to mature: for example, the research will look for possible correlations with student outcome data, and whether they are present in pilot schools in which CoolThink implementations have been sustained. Based on data at midline, the following are emerging as preliminary factors likely to predict a successful CTE implementation:

1. **Student experience of active learning pedagogy and high levels of engagement with CoolThink lessons.** Based on data so far, CoolThink's active lessons and opportunities for creativity have the potential to inspire students' learning and engagement, particularly in units based on Scratch.
2. **Access for students to the full range of creative and design tasks built into CoolThink@JC, including the final project.** As teachers adapt CoolThink lessons for accessibility and to fit into available time, support and training toward productive modifications rather than simple streamlining can help preserve these important opportunities for creativity and design for all students.
3. **Teacher access to comprehensive professional development on computational thinking and readiness to teach CoolThink@JC.** The professional learning offered as part of CoolThink@JC is proving to be an essential enabler for teachers who are adopting the lessons and must be preserved as CoolThink@JC continues to scale to more schools.
4. **Teacher confidence incorporating computational thinking into their instruction and perspectives on the accessibility of CoolThink materials.** As teachers gain experience with CoolThink implementation, their capacity to integrate computational thinking concepts, practices, and perspectives into their instruction and their experience of CoolThink materials as accessible both for themselves and their students will be important factors driving success.
5. **School leader support for innovation and for the place of computational thinking education in the primary school curriculum.** These important priorities are espoused more strongly among school leaders in CoolThink network schools relative to their counterparts who have not yet engaged, making it a potentially important focus for the initiative moving forward.

As CoolThink@JC continues to scale beyond the first 200 network schools, The Trust and its partners may want to consider strategies to address the following challenges:

- **Identify productive and unproductive modifications to CoolThink materials.** Most teachers modify CoolThink lessons in order to complete units in the time allotted to them or meet the needs of diverse learners. In many cases, these modifications are helpful: they make adoption of CoolThink materials more feasible and enable teachers to integrate CoolThink lessons with existing curriculum. Other modifications, however, are counterproductive: they may enable students to complete lesson activities, but at the expense of developing deep conceptual understanding and computational thinking skills. As teachers begin to adopt CoolThink materials without the benefit of extensive training, it will be important to understand what kinds of modifications constrain students' opportunity to learn and what kinds of modifications support learning, and to help teachers to understand the difference.
- **Develop strategies for providing additional support to teachers and students in high-need schools.** Ensuring equitable access to high-quality curriculum and instruction for all Hong Kong students is central to The Trust's mission. Data collected at midline show small but consistent differences in students' experiences of CoolThink, depending on which school they attend. As the initiative continues to scale, The Trust can continue to explore the particular needs and challenges faced by schools and classrooms enrolling large numbers of students performing below grade level, special educational need (SEN) students, and students from low-income families. With greater insight into the particular experiences of these schools and teachers, The Trust will be better positioned to expand investments in high-priority, high-need schools.
- **Continue to build the professional development infrastructure for future CoolThink teachers.** EdUHK will no longer be able to offer its series of four 12-hour teacher development courses after the CoolThink@JC scaling phase ends. Other organizations have begun to develop promising alternatives, but it remains to be seen whether they will be as effective for teachers as CoolThink's more intensive teacher development courses. Uptake of existing alternatives has been low among network schools, and teachers who have not taken a development report lower levels of preparation to teach CoolThink@JC.
- **Build enthusiasm for computational thinking in schools beyond the network.** On average, schools that have not volunteered for the CoolThink network are starting with less principal and teacher commitment to computational thinking, so while encouragement from EDB will be helpful it may not be sufficient to incent the hard work of adoption. More robust accompanying PD that does not require network membership might be attractive, and partners should consider additional ways to build enthusiasm prior to adoption.
- **Continue to focus on succession planning.** A key aspect of successful scaling is shift in reform ownership (Coburn, 2003). During CoolThink's pilot and scaling phases, The Trust's Central Coordinating Committee has convened partner organizations and stakeholders and coordinated activities in support of scaling goals. As the

initiative enters its final 18 months, it will be important to enact transfers of responsibility to those who will assume ownership of the initiative after The Trust's support ends. The Hong Kong Education Bureau is playing a particularly critical role in advancing computational thinking education throughout the territory in the coming years. Other components of the ecosystem, including teachers' associations and university-based professional development providers, will also be important ongoing. The Trust's CCT may want to consider how other convening and management functions could, ideally, be taken up by another organization or network.

- **Build on CoolThink@JC to advance a broader technology education agenda and expand CTE to secondary schools.** Systems-level leaders argued that CoolThink@JC at the primary level has the greatest chance for sustainability if it becomes part of a curriculum progression that includes CTE and computer science coursework at the secondary level. When computational thinking and related 21st-century skills (critical thinking, problem-solving and creativity) are priorities at the secondary level, CoolThink@JC will gain even greater traction in the primary curriculum. In addition, The Trust could consider ways to build on CoolThink@JC as the cornerstone of a wider investment in technology education that develops students' digital creativity, digital literacy, and digital citizenship at all ages.

In the final phase of this implementation study, SRI will continue to weigh the evidence supporting the success factors identified in this midline report (and others that may emerge in the analysis conducted for the endline report) and revise the CoolThink@JC implementation model to align with this evidence. Looking ahead to the endline report, we expect the success factors and implementation model validated in this implementation study will inform The Trust's efforts to showcase the CoolThink model beyond Hong Kong and to drive thought leadership in CTE, AI learning, and technology education more broadly.

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