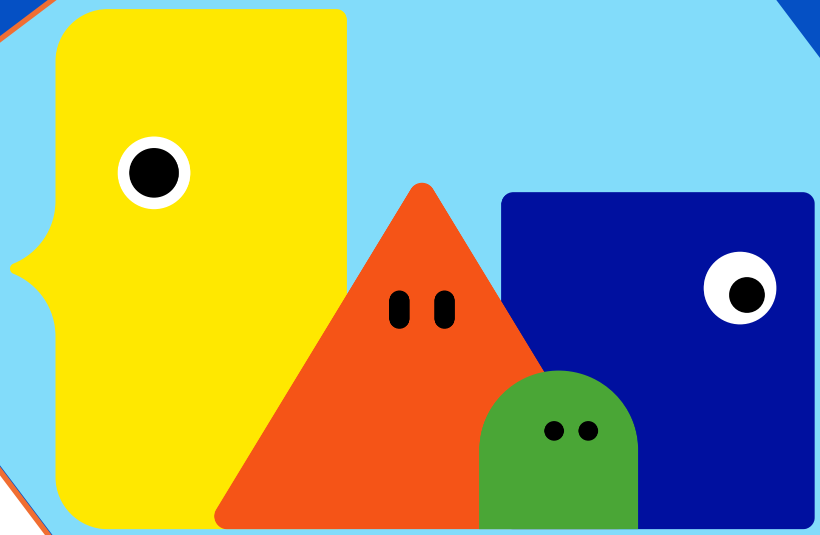

Scaling Up CoolThink@JC

Implementation Study Endline Report

April 2025

Created and Funded By

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Contents

List of Exhibits

Foreword

This report is the last in a series from SRI Education on the scaling of CoolThink@JC in Hong Kong primary schools. SRI's evaluation of CoolThink@JC began with a study of the program's impact on students' computational thinking knowledge, skills, and perspectives during a 32-school pilot between 2016 and 2019. When The Hong Kong Jockey Club Charities Trust (The Trust) launched the program's scaling phase in 2020, SRI undertook an implementation study of The Trust's scaling strategies, seeking to identify success factors and implementation considerations that would inform replication efforts in other jurisdictions. SRI's reporting on this implementation study includes both midline and endline reports, as well as two special reports on topics of particular interest to CoolThink partners and to The Trust.

The other reports in SRI's series on CoolThink@JC can be found at the following links:

- *CoolThink@JC Pilot Evaluation Endline Report* (English)
- *Global Benchmarking of Computational Thinking Education in Primary Schools* (English)
- *Scaling Up CoolThink@JC: Implementation Study Midline Report* (English)
- *Where Are CoolThink Students Making the Greatest Learning Gains? Linking CoolThink@JC Implementation with Student Outcomes* (English)

The report authors would like to thank the CoolThink teachers, principals, mentors, and governance committee members who gave so generously of their time to participate in multiple rounds of surveys and interviews for the implementation study.

We thank Daniel Lai, Paul Yau, and Bruce Au of The Trust for their steadfast support and guidance throughout the pilot and implementation studies. Their vision and advice has been critical to shaping this report and the entire series listed above.

KaYan Poon, Stephanie Ho, Lydia Siu, and Mark Mok of Ipsos undertook nearly all of the data collection for the CoolThink@JC implementation study, including administering teacher and school leader surveys and conducting school site visits. We thank this team for their collaboration and partnership and are deeply grateful for their contributions to the study. Christine Yuen provided expert simultaneous interpretation for SRI researchers who needed to conduct interviews in Chinese. We thank Professor Kong Siu Cheung and Dr. Lai Ming of the Education University of Hong Kong for sharing the student assessment data that informed SRI's second topical report and for their advice and guidance throughout the study. Yesica Lopez of SRI has provided expert project management for the SRI team since the inception of the pilot study in 2016. We thank her for making our work possible.

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 Hong Kong. By summer 2024, in the final year of the initiative's scaling phase, a critical mass of primary schools had adopted the 14-hour curriculum. Nearly all other primary schools had received CoolThink course materials to pilot and had also attended one or more CoolThink-sponsored workshops. The Trust had also identified teacher professional development providers and teacher networks to train new CoolThink teachers after the end of the initiative's scaling phase.

This report presents findings of a study conducted by SRI International (SRI) since the CoolThink scaling phase launched in the 2020–21 school year, offering a rich opportunity to understand what happens when a promising new instructional initiative is enacted by many more schools and teachers. The report describes the implementation and sustainability of CoolThink@JC at three nested levels: the classroom level, the school level, and the system level. It also describes the success factors that have been critical to achieving depth and sustainability of the initiative as it scales.

CoolThink at the classroom level

Across CoolThink network schools at scale, CoolThink instruction featured more student-centered learning and more opportunities for problem-solving than prior information and communication technologies (ICT) classes. Creativity, problem-solving, and student-centered learning were described by both teachers and students as key hallmarks of CoolThink classrooms.

These types of learning opportunities were substantially more evident in classes where CoolThink materials were used as designed (rather than streamlining or simplifying to adapt them to a given class). Teachers in lower-ability classrooms were much more likely to feel the need to make these adaptations in order to make materials more accessible to their students, highlighting the importance of attending specifically to the diverse needs of a range of classrooms when designing educational initiatives. Teachers' most significant challenges remained meeting the needs of students of different skill levels and fitting instruction into the available time.

CoolThink at the school level

In order to bring CoolThink's benefits to a wider range of students and classrooms, ongoing development of teacher capacity for computational thinking instruction was a key success factor for CoolThink@JC. The teacher development courses offered by the CoolThink team provided essential support for teacher preparation, particularly when complemented by supplemental activities such as coaching. On average, 79% of teachers reported at least some confidence in teaching CoolThink's primary goals of computational concepts, practices, and perspectives after at least one year of participation in CoolThink@JC, compared with 45% of the same teachers in the months before they began teaching CoolThink lessons. School leader support was consistently associated with higher levels of teacher capacity and more student-centered forms of instruction.

The adoption of CoolThink@JC by network schools catalyzed a shift in the overall character of ICT instruction toward a greater focus on computational thinking. The majority of CoolThink teachers extended the class time devoted to CoolThink lessons beyond the recommended 14 hours, with CoolThink teachers spending an average of 19 hours on CoolThink lessons for a given class of students. School leaders typically accommodated this additional time for CoolThink@JC within the school schedule by reducing the time allocated to other ICT topics. This willingness to expand the class time available to CoolThink instruction suggests that teachers and school leaders find value in CoolThink lessons and their support for computational thinking as an essential component of the regular primary school curriculum.

More than 7 years after first adopting CoolThink materials, most Cohort 1 and 2 schools reported that they were still teaching CoolThink courses. These schools' continued use of CoolThink course materials over many years since the end of the pilot phase confirms that CoolThink instruction can be self-sustaining beyond the period of schools' active participation in network activities. Among pilot-phase schools, strong school-based teams of experienced CoolThink teachers were the most important resource for training new teachers and sustaining teacher capacity to teach CoolThink@JC.

CoolThink at the system level

As a catalyst for ecosystem development, the CoolThink governance structure ensured active support and buy-in from key system-level actors who support computational thinking education (CTE) in Hong Kong. The professional collaborations promoted by the initiative's various committees have contributed to the development of three key components of a robust CTE ecosystem: (1) a new policy from the Hong Kong Education Bureau (EDB) that requires enriched coding education in all Hong Kong primary schools, supplemented by model curriculum materials adapted from the CoolThink courses; (2) a constellation of initiatives and programmatic offerings that builds public awareness of the value of CTE; and (3) networks of CoolThink teachers and professional development providers who have and will continue to champion CTE and prepare teachers to teach CoolThink@JC effectively.

Conclusion: Success factors supporting depth and sustainability of scaling

Nearly a decade after The Trust and its partners conceived of an initiative to promote computational thinking among primary students in 32 Hong Kong pilot schools, CoolThink curriculum materials and teacher development courses have shifted the focus of ICT instruction across 204 network primary schools and have brought awareness and supported initial changes in many more. Within most network schools, the focus of ICT learning is moving beyond technology consumption and digital literacy toward a focus on creation and problem-solving. The sustained use of CoolThink materials and implementation of courses as they were originally designed in early-adopting pilot schools suggests that these shifts will continue to benefit students in years to come.

The multilevel design of CoolThink's scaling strategies (classroom, school, system) is a hallmark of the initiative and may be a model for educators and education leaders in other jurisdictions who are planning to launch a curriculum-driven CTE reform effort. Key success factors that have emerged from this study of CoolThink@JC implementation over the initiative's scaling phase include:

- Students' experience of active learning pedagogy and high levels of engagement with CoolThink lessons
- Materials that are understandable and correctly paced for the majority of students
- Comprehensive teacher development aligned with a fully articulated set of instructional materials to prepare teachers to teach CoolThink@JC
- School-level conditions to sustain CoolThink@JC, including school leader support for innovation and for the place of computational thinking in the primary school curriculum, as well as strong CoolThink teacher teams
- Strategic system-level ecosystem-building strategies that set the stage for successful transfer of ownership of the initiative once The Trust's support ends

As the scaling phase of CoolThink@JC draws to a close, ownership and support for schools and teachers is transitioning from The Trust and its partners to a broader ecosystem of CTE leaders and stakeholders across Hong Kong. Participants in this ecosystem have been thoughtfully recruited over the course of this initiative, and CoolThink@JC is well positioned for sustainability. Important considerations toward maximizing ongoing success include (1) a continued focus on helping teachers adapt lessons to their own classroom contexts, including diverse student skill sets and time limitations, without compromising the creativity and problem-solving that CoolThink@JC is designed to encourage; (2) incentive structures for schools that are yet to adopt; and (3) continued work to create a coordinated pathway for computational thinking through the upper grades so that students will graduate ready to lead Hong Kong into the fast-changing digital future.

Scaling Up CoolThink@JC

Implementation Study Endline Report

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Introduction

CoolThink@JC is a 3-year course sequence designed to introduce computational thinking to students in the upper primary grades with the stated mission of "nurtur[ing] students' proactive use of technologies for social good from a young age, … prepar[ing] them for a fast-changing digital future through a hands-on, minds-on, and joyful learning experience."[1] Created and funded by The Hong Kong Jockey Club Charities Trust (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). In 2020, after a successful pilot in 32 schools, CoolThink@JC's co-creators undertook an ambitious initiative to scale the program to all Hong Kong primary schools. By demonstrating success at scale, the CoolThink partners hoped to create a new paradigm for computational thinking education (CTE) at the upper primary level and to have CoolThink@JC serve as an international model for other jurisdictions as they seek to establish CTE in the primary grades.

CoolThink implementation model

CoolThink@JC is a multifaceted initiative targeting classrooms, schools, and the territory-wide ecosystem supporting CTE in the upper primary grades. The program's key components include a comprehensive, sequenced set of curriculum materials that could be tailored for school-based curricula, intensive teacher professional development to support effective CoolThink instruction, workshops to support public awareness of and parent engagement in CTE, and system-level capacity-building activities (see Appendix A).

Following a successful pilot in 32 schools from 2016 to 2019, the CoolThink partners developed a range of scaling strategies designed to make the program less resource-intensive, to lower barriers to adoption, and to build capacities for success and sustainability within the system (see box). These scaling strategies reduced CoolThink@JC's per-student cost by almost two thirds during the scaling phase, compared with the pilot (HKD$3,613 or USD$463 per student during the scaling phase, compared with HKD$9,343 or USD$1,198 per student during the pilot).

[1] The complete text of the CoolThink mission statement is included in Appendix A.

Leveraging these resources and lessons learned during the pilot phase, the CoolThink partners set out to create (1) a critical mass of CoolThink adoption in primary schools, (2) system-level capacity to train and support CoolThink teachers, (3) public awareness and support for CTE, (4) upgraded tools and infrastructure, and (5) intellectual leadership for CTE. The partners expected that a robust CTE ecosystem with these five elements would then support strong, sustained implementation of CoolThink materials and lead to desired gains in students' computational thinking knowledge, skills, and perspectives.

CoolThink@JC Key Components for Scaling

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

- Three 14-hour lesson sequences and accompanying instructional materials that reflect the program's key design principles (e.g., to play, to think, to code, to reflect pedagogy) and incorporate cutting-edge technology (e.g., artificial intelligence [AI] and robotics).
- Two sets of co-curricular materials (designed to be used either in afterschool programs or to supplement CoolThink courses offered during the regular school day). These co-curricular materials address multiple advanced topics, including application of AI tools, robotics, the internet of things, and design thinking.
- Support for school-level tailoring of the CoolThink curriculum, with options for designing specialized course pathways, streamlining lesson sequences, and/or supplementing or enriching lessons.
- Modular foundational teacher development courses that require substantially fewer hours in training (12 hours for each of 4 courses) compared with teacher professional development 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 professional development opportunities available to all schools and offered by multiple providers. These include, for example, workshops sponsored by the Hong Kong Education Bureau (EDB), InnoCommunity workshops led by pilot-phase mentor teachers, training for pre-service teachers provided by the University of Hong Kong (HKU) Faculty of Education, and courses at the MIT HK Innovation Node.
- Parent engagement workshops, coding fairs, and student competitions.
- Validated annual assessments of students' computational thinking concepts, practices, and perspectives aligned with CoolThink instructional objectives.
- Strategic partnerships with EDB, school sponsoring bodies, and non-governmental organizations to develop a territory-wide ecosystem in support of CTE.

By summer 2024, as the CoolThink@JC initiative was entering the final year of its scaling phase, 204 schools in six cohorts had adopted the 14-hour curriculum. An additional 273 primary schools had received CoolThink course materials to pilot and had also attended one or more CoolThink-sponsored workshops; these additional schools accounted for all of the remaining publicly aided primary schools in Hong Kong. The Trust had also worked to identify or establish teaching professional development providers and teacher networks that could train new CoolThink teachers after its support for the initiative has ended.

Implementation study

To capture the lessons learned from this scaling effort, SRI's implementation study was designed to assess the extent to which schools' adoption of CoolThink@JC is consistent with the initiative's design principles and is 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 the CoolThink@JC scaling experience. The study sought 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 professional development at scale? How do teacher perceptions and self-reported outcomes vary in response to scalable models of professional development?
4. What implementation factors are associated with stronger student outcomes?
5. To what degree is a sustainable territory-wide ecosystem in support of computational thinking in evidence in Hong Kong? What elements of the system-level context appear to support scaling and sustainability of CoolThink@JC?

Data sources for the implementation study included surveys of large, representative samples of CoolThink teachers and school leaders and more in-depth data collection in small, purposive samples (e.g., educator interviews, classroom observations, classroom logs, professional development observations, system-level interviews, and out-of-network surveys). Exhibit 1 on the following page summarizes each data source informing this endline report, the time periods covered, and sample sizes, including response rates. Additional detail on data sources, samples, and methods can be found in Appendix B.

In this report, we present streamlined summary exhibits drawing on aggregate measures, or we present just a subset of survey items for the sake of brevity. Except as noted, all contrasts we present in the main report are statistically significant ($p < .05$). For the full version of every report exhibit, including all item-level responses and results of significance testing, see Appendix C.

Exhibit 1. Implementation study data sources

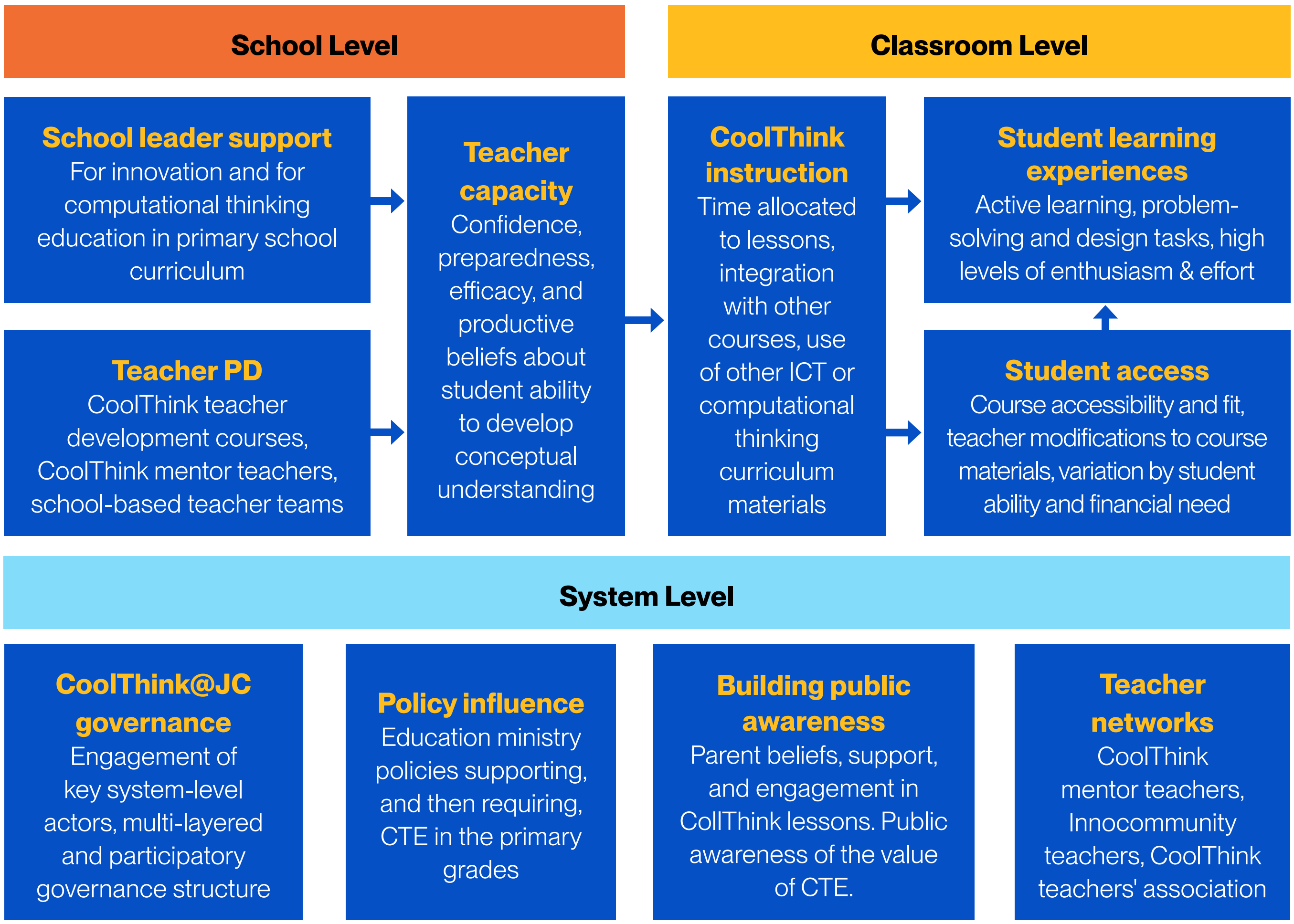
	Instrument	School year(s)	Sample	Number of respondents / response rate
CoolThink implementation, 2022–23	Teacher follow-up survey summer 2023	2022–23 (Cohort 3 Y3, Cohort 4 Y2, Cohort 5 Y1)	All Cohort 3, 4, and 5 teachers	512 teachers / 55%
	School leader follow-up survey summer 2023	2022–23 (Cohort 3 Y3, Cohort 4 Y2, Cohort 5 Y1)	All Cohort 3, 4, and 5 schools	118 schools / 81%
	CoolThink classroom logs	December 2022–June 2023 (6 monthly logs)	59 Cohort 3–5 schools, up to 5 CoolThink teachers, and 5 lessons per teacher	806 logs / 58% 220 teachers / 79%
	School site visits	June–July 2023	Purposive sample of Cohort 3, 4, and 5 schools	17 teachers, 9 school leaders, 95 students, and 16 observations in 10 schools
	Sustainability survey (school leaders)	2022–23 (Cohort 1 Y7, Cohort 2 Y6)	All Cohort 1 and 2 school leaders	28 schools / 88%
Baseline	Teacher baseline surveys	2020–21 (Cohort 3), 2021–22 (Cohort 4), 2022–23 (Cohort 5)	All Cohort 3, 4, and 5 teachers who also responded to a follow-up survey in 2022–23	410 teachers / 44%
	School leader baseline surveys	2020–21 (Cohort 3), 2021–22 (Cohort 4), 2022–23 (Cohort 5)	All Cohort 3, 4, and 5 schools that also responded to a follow-up survey in 2022–23	104 schools / 71%
	Out-of-network school leader survey	2020–21	Representative sample of public sector primary schools (aided, direct subsidy scheme, government)	206 school leaders / 51%

Earlier findings from SRI's implementation study (Laguarda et al., 2023, 2024) point to a set of implementation "success factors" that we hypothesized would lead to sustained CoolThink adoption and desired student outcomes (see Exhibit 2). We identified these as success factors for one or more of the following reasons:

- They reflect a hallmark of CoolThink@JC's design, and in fact, CoolThink lessons differed significantly from prior business-as-usual information and communication technologies (ICT) lessons on the dimensions that describe instruction.
- They varied across classrooms and schools, often by students' ability levels.
- They were correlated with more positive student computational thinking outcomes.

- They were correlated with each other in ways that are consistent with CoolThink@JC's theory of action.
- System-level observers consistently identified them as a key resource for CoolThink@JC's successful scaling.

Exhibit 2. CoolThink success factors



This final endline report takes these success factors as its organizing framework, beginning with the classroom level and working out to the ecosystem. It describes CoolThink implementation in 146 schools in Cohorts 3–5, one to three years after adoption of CoolThink@JC. It also describes the ecosystem for sustaining CoolThink@JC at scale, highlighting the success factors that observers believe were critical to achieving depth and sustainability of the initiative.

CoolThink at the Classroom Level

Key Findings

- Active learning, problem-solving, creativity, and design thinking are demonstrated hallmarks of CoolThink classrooms at scale. Students engage in active learning and problem-solving more often in CoolThink lessons compared with their previous ICT lessons.
- Both teachers and students highlighted opportunities for creativity, problem-solving, and student-centered learning as key features of CoolThink classrooms.
- CoolThink materials are more accessible (both in terms of understandability and pacing) for higher-ability students. Teachers in higher-ability classrooms were much more likely to report that CoolThink materials were a good fit for their students and were more likely to say that their students benefited from CoolThink lessons.
- Nearly all CoolThink teachers reported modifying CoolThink course materials to tailor them to student needs, but teachers in lower-ability classrooms were more likely to modify CoolThink materials in ways that might mitigate the opportunities for creativity and problem-solving that CoolThink@JC is known for.

CoolThink course materials are designed to support hands-on, minds-on learning and high levels of student engagement in learning tasks. Over the course of a 3-year pilot, CoolThink teachers reported that the lesson materials supported 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 (Shear et al., 2020). Scaling to a larger set of schools asks a more diverse set of educators to adopt the student-centered teaching practices on which CoolThink@JC's design is founded. This section describes student learning experiences in CoolThink classrooms, the ways in which student access to the full CoolThink learning experience varies, the choices that teachers make when planning CoolThink lessons, and whether classrooms at scale remain consistent with CoolThink@JC's original design goals.

Student learning in CoolThink classrooms

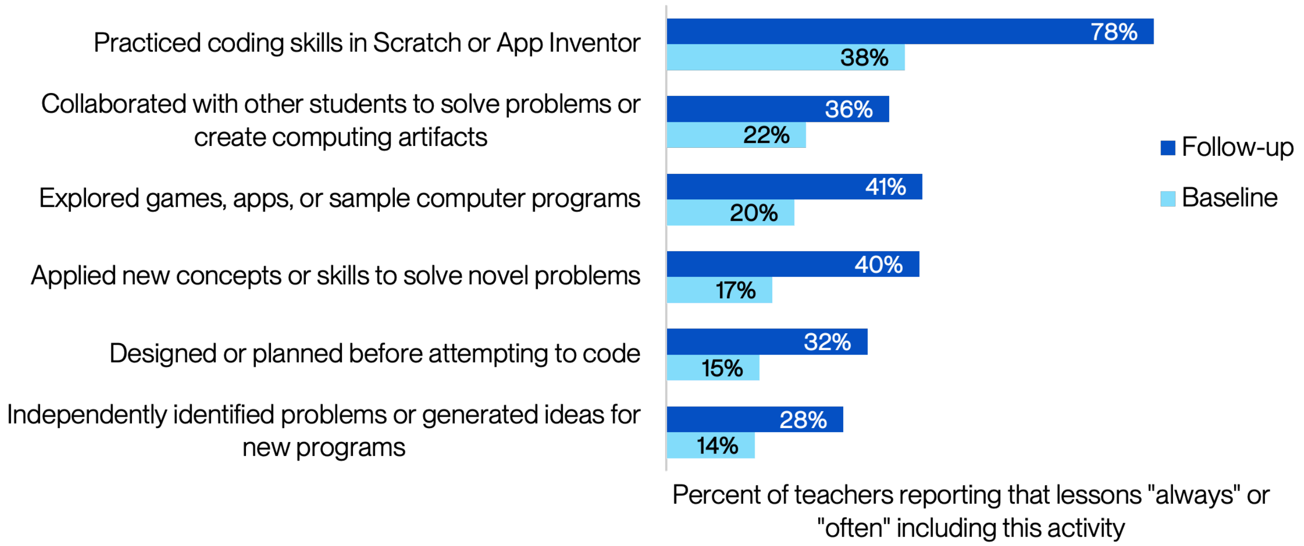
Previous research (Shear et al., 2020) has established that CoolThink instruction that is consistent with the course materials' design supports important computational thinking outcomes, including greater gains in computational thinking concepts and practices. At scale, we can expect students' experiences of CoolThink@JC, and therefore their learning, to vary depending on how the lessons are taught in a wide variety of classrooms. This implementation study examined students' experiences of CoolThink@JC at scale, which are described here with an emphasis on what learning experiences are like in classrooms where CoolThink implementation is strong.

Students experienced more active learning, more problem-solving, and more design-thinking tasks in CoolThink classes compared with their previous ICT lessons.

Based on surveys of teachers about their CoolThink classes (after one, two, or three years depending on the cohort) and about the ICT classes they used to teach (at baseline), students engaged more frequently in active learning and programming tasks in CoolThink classes compared with their previous ICT lessons (Exhibit 3). This finding is an important indication that many of the defining attributes of CoolThink instruction—including unstructured exploration prior to specific instruction, student agency in planning the programs they will write rather than following step-by-step instructions, and other important design features—were present in many classes at scale.

This difference between learning tasks in CoolThink classes compared with previous ICT lessons held for all cohorts of CoolThink schools (see Appendix C, Exhibits C2—C4). Cohort 3 schools, which were the first to begin using CoolThink@JC and had up to 3 years of experience teaching CoolThink lessons, were most likely to report engaging in active learning and programming tasks. The progression across the cohorts suggests that on average, teachers' use of active learning pedagogies increased with time and CoolThink experience.

Exhibit 3. Relative to previous ICT lessons, CoolThink students spent more time programming and more time in active learning and problem-solving tasks



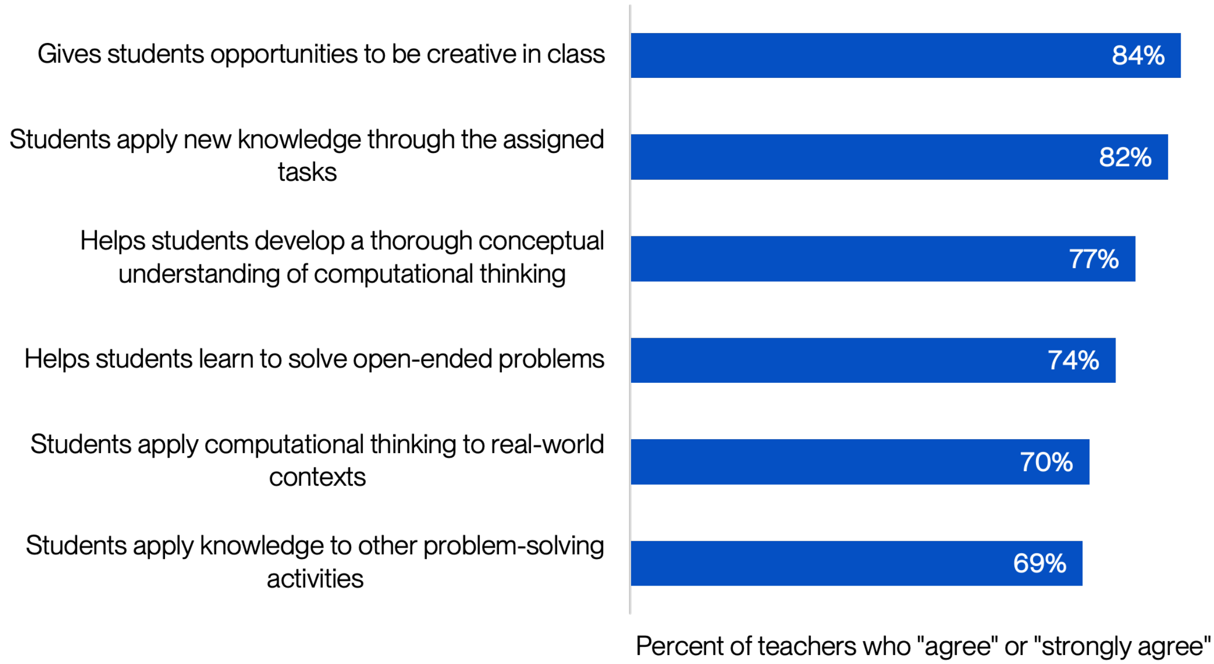
Note: *All contrasts between baseline and follow-up are statistically significant. For the full version of this exhibit, including all item-level results by cohort, see Appendix C, Exhibits C1—C4.*
Sample: *n = 307. Sample restricted to teachers who responded at both baseline and follow-up.*
Source: *Cohort 3–5 baseline teacher survey (fall 2020, 2021, 2022) and Cohort 3–5 follow-up teacher survey (summer 2023).*

Although students completed activities related to problem-solving and active learning significantly more frequently than in previous ICT lessons, Exhibit 3 shows that the frequency of some of these important design elements remained low, with fewer than half of teachers reporting that students "always" or "almost always" engaged in these activities. Practicing coding was by far the most common activity in CoolThink classrooms.

Both teachers and students highlighted opportunities for creativity, problem-solving, and student-centered learning as key hallmarks of CoolThink classrooms.

The vast majority of CoolThink teachers believed that beyond teaching students to code, CoolThink instruction helped students develop creativity and problem-solving skills, with 84% agreeing or strongly agreeing that CoolThink@JC gave students opportunities to be creative in class and 74% agreeing or strongly agreeing that it helped them learn to solve open-ended problems (Exhibit 4). Teachers also reported that students were enthusiastic participants and demonstrated effort in completing CoolThink tasks (see Appendix C, Exhibit C5).

Exhibit 4. Large majorities of teachers agreed that CoolThink supports creativity and problem-solving



Note: *For the full version of this exhibit including all item-level results, see Appendix C, Exhibit C5.*
Sample: *Cohort 3–5 follow-up n = 497.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

In interviews, teachers identified problem-solving, critical thinking, and collaboration as key elements of the CoolThink learning experience, noting that CoolThink@JC taught these skills systematically and offered students more opportunities to develop these skills than lessons in other subject areas did. Teachers described the steps they took to stimulate students to think, to make connections to real-life ideas, to help students persist in solving problems on their own, and to make sure students had fun, in order to promote motivation and interest (see box for examples). One teacher described CoolThink's approach to open-ended problem-solving in this way:

> **Because CoolThink [does not tell students how] to solve problems or what the answer is, students can use their creativity when testing and debugging, and cooperate with classmates when doing more difficult coding.**
>
> **– CoolThink teacher**

In focus groups, students explained that CoolThink@JC helped them learn and practice solving problems logically, have patience and persistence in tackling unfamiliar tasks, and effectively collaborate with other students. They also described how CoolThink@JC had taught them that programming was more interesting than they had expected it to be.

> **It's a whole new world for me. Most people including me only looked at the game itself. Now, I know how it's made.**
>
> **– CoolThink student**

> **I read my sister's textbook when I was younger, it was something about Python ... Then, I thought coding was boring and difficult. Now, I would say it's fun.**
>
> **– CoolThink student**

> **I thought coding was so complicated and difficult before. I can't believe I'm coding and designing a game. It makes me feel that I am smart and clever.**
>
> **– CoolThink student**

Examples of high engagement with problem-solving in CoolThink classrooms

In one classroom, students worked with a high level of autonomy and independence, with the teacher providing only occasional guidance. Students were encouraged to use their creativity and complete all coding processes independently, including deciding what and how to code and solving any problems that arose throughout the process. Students were highly engaged, frequently conducting tests and debugging their code, and discussing issues they encountered with their peers. They frequently consulted the workbook and introduction video to get ideas about errors in their code.

In another classroom, the teacher worked with individual students to provide hints and encouraged them to brainstorm solutions, guiding them to solve the problem on their own. She would only offer corrections after first seeing students' efforts and their reasoning. For example, when one student struggled to turn a cat around in Scratch, the teacher asked prompting questions, such as "What do you want the cat to do for the next step?" "Do you remember what we discussed before?" "What tool can you use?" and "What is the purpose of this tool?"

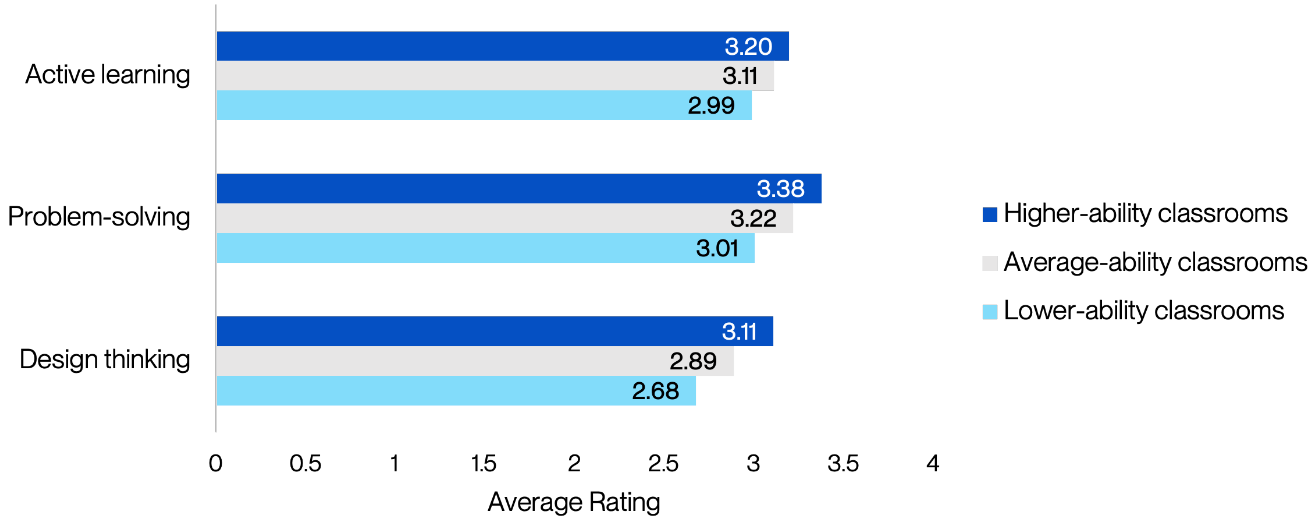
Source: *CoolThink classroom observations.*

Teachers used active learning strategies and focused on problem-solving more frequently when their classes had more students performing above grade level.

Although CoolThink lessons provide an opportunity for a clear departure from regular ICT instruction, students' experiences of CoolThink instruction varied by ability level. For the implementation study, classrooms were classified as higher ability, average ability, and lower ability based on teacher reports on both surveys and classroom logs. Teachers reported the percentage of students performing at grade level, above grade level, and below grade level across all their CoolThink and ICT classes (on the surveys) or in that day's logged lesson (on the logs). On average, higher-ability classrooms had more than 50% of students performing above grade level, and lower-ability classrooms had more than 50% of students performing below grade level. (See Appendix B for detail.)

Students in higher-ability classrooms engaged in active learning, problem-solving, and design thinking more frequently than students in lower-ability classrooms did (Exhibit 5). Compared with students in lower-ability classrooms, students in higher-ability classrooms received more opportunities for collaborative work, such as sharing work or computing artifacts with other students; engaging in unstructured exploration of games or sample computer programs; and solving novel problems and creating computing solutions.

Exhibit 5. Teachers in higher-ability classrooms used active learning, problem-solving, and design thinking strategies more frequently



Note: *Active learning and problem-solving are the average of survey items rated on a scale from 1 (never) to 5 (always). Design thinking is an average of items rating on a scale from 1 (not at all) to 4 (to a great extent). All presented contrasts are statistically significant. For the full version of this exhibit including all item-level results, see Appendix C, Exhibits C6—C9.*
Sample: *Higher-ability classrooms n = 111, Average-ability classrooms n = 193, Lower-ability classrooms n = 133.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

As shown in Appendix C (Exhibit C9), teachers in higher-ability classrooms were consistently more likely to report on surveys that their students engaged in design thinking tasks during their final projects than teachers in lower-ability classrooms. These differences are also reflected in classroom log data, which show that students in lower-ability classrooms were less likely to spend significant class time engaged in designing and planning a computer program or artifact before attempting to code. In lower-ability classrooms, students spent more than 10 minutes designing and planning a computer program or artifact in 23% of logged lessons, compared with 35% of logged lessons in higher-ability classrooms.

Finally, students in average- and higher-ability classrooms demonstrated higher levels of enthusiasm, effort, and interest, according to CoolThink teachers.

Student access: Course fit and teacher modifications

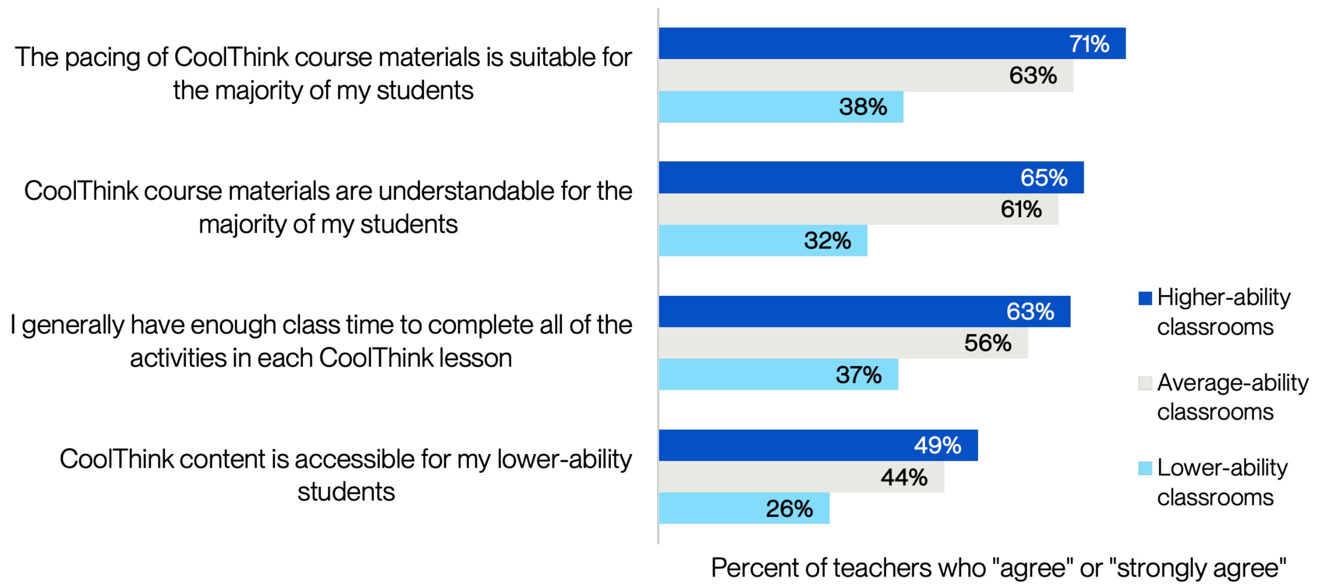
SRI's second topical report, which looked at the relationship between implementation factors and student outcomes, found a strong student benefit when teachers taught the CoolThink lessons without modifications (Laguarda et al., 2024). Data from teacher surveys, classroom instructional logs, and interviews collected for this implementation study explain this relationship, by demonstrating that modifications to CoolThink course materials are often driven by the need to streamline and simplify the CoolThink lessons for a given class, reducing the time available for student problem-solving. Teaching CoolThink@JC without modifications tends to be more prevalent in higher-ability classes and in Scratch than in MIT App Inventor lessons.

Teachers in higher-ability and average-ability classrooms were more likely to report that CoolThink course materials were a good fit for their students, compared with teachers in lower-ability classrooms.

The large majority of teachers in lower-ability classrooms reported that most of their students, especially their lower-ability students, had difficulty understanding the CoolThink course materials (Exhibit 6). Teachers in lower-ability classrooms were also more likely to report significant time pressures: The large majority reported that the pacing of CoolThink lessons was too fast for their students and that they generally did not have enough class time to complete all activities in each CoolThink lesson. Teachers reported the same time pressures in classroom logs: Just over half of teachers in higher-ability classrooms (53%) reported that they had been able to complete an entire CoolThink lesson in the class they had logged, compared with 36% of teachers in lower-ability classrooms. Similarly, teachers in higher-ability classrooms were more likely to report that they had enough time to get through all of the content they had planned for the day's lesson (85% of teachers in higher-ability classrooms vs. 71% of teachers in lower-ability classrooms).

On survey questions about CoolThink@JC's accessibility and fit, teachers in lower-ability classrooms were consistently less likely to agree that CoolThink materials worked well for their classrooms and their students (see Appendix C, Exhibits C11).

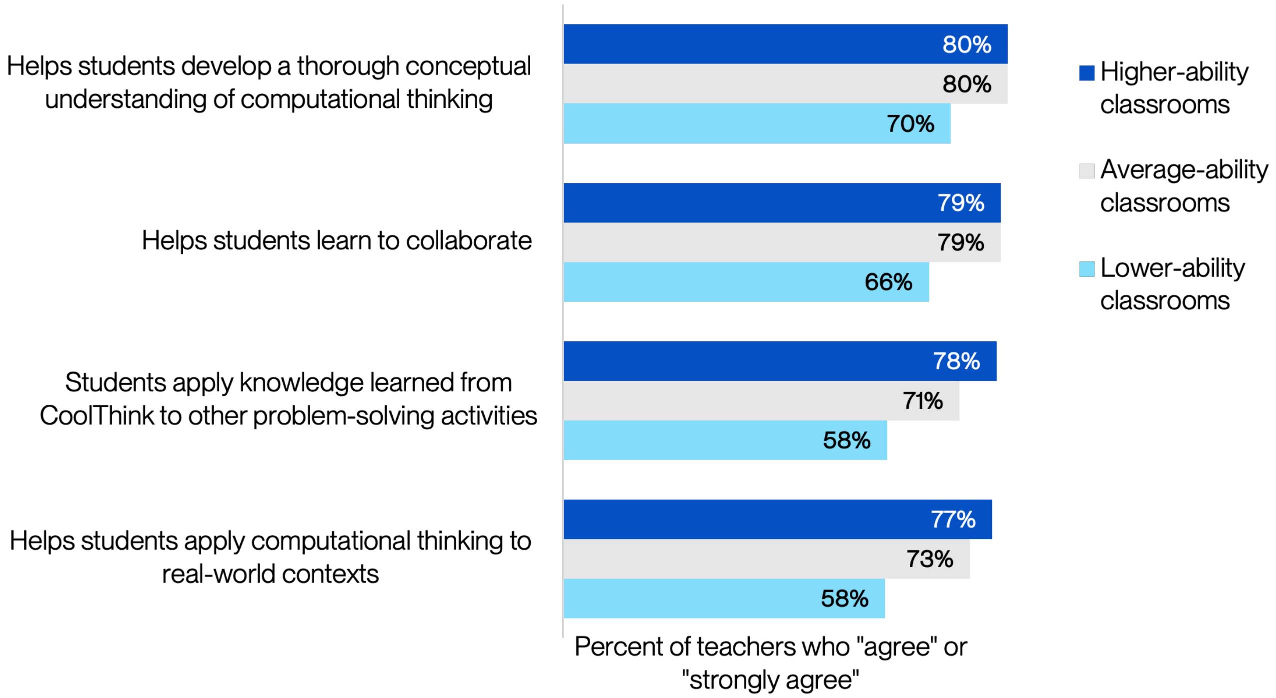
Exhibit 6. More teachers in higher-ability classrooms considered CoolThink materials a good fit for their students, compared with teachers in lower-ability classrooms



Note: *All presented contrasts are statistically significant. For the full version of this exhibit including all item-level results, see Appendix C, Exhibit C11.*
Sample: *Cohort 3–5 follow-up, Higher-ability n = 127, Average-ability n = 216, Lower-ability n = 152.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

Consistent with their judgement about CoolThink@JC's accessibility and fit for their students, teachers in lower-ability classrooms were also more reserved in assessing the program's benefits for student learning. For example, teachers of lower-ability classrooms were much less likely to agree that CoolThink@JC helps develop deep conceptual understanding and problem-solving skills and that students can transfer skills from CoolThink@JC to other contexts (Exhibit 7). Teachers in higher-ability classrooms were the most likely to agree that CoolThink@JC helps students acquire these skills.

Exhibit 7. Teachers in higher-ability classrooms were most likely to believe that CoolThink develops students' conceptual understanding and problem-solving skills

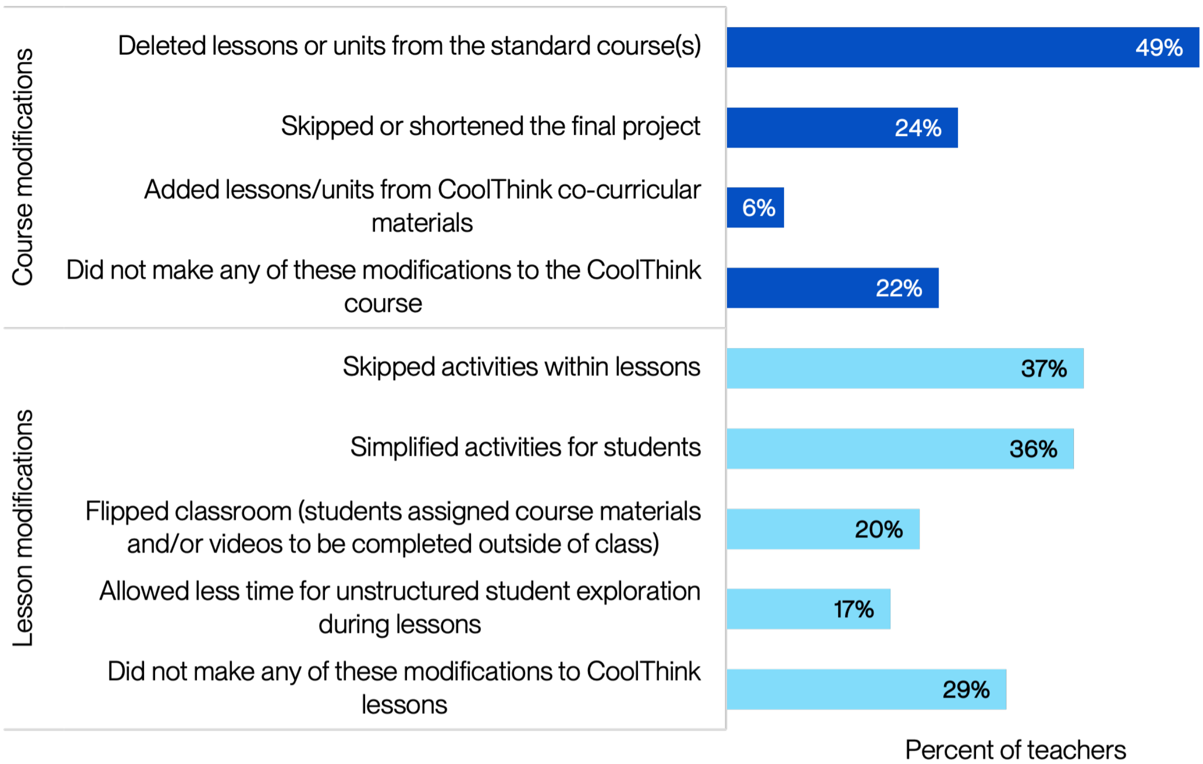


Note: *All presented contrasts are statistically significant. For the full version of this exhibit including all item-level results, see Appendix C, Exhibit C12.*
Sample: *Cohort 3–5 follow-up, Higher-ability n = 127, Average-ability n = 216, Lower-ability n = 151.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

Nearly all CoolThink teachers reported modifying CoolThink course materials in some way, either by deleting or streamlining lessons or units or by simplifying activities for students.

Teachers reported making modifications to about 70% of CoolThink lessons logged in 2022–23, either by skipping activities or by modifying the materials to better meet student needs. On surveys, nearly half of teachers said they modified the standard CoolThink courses by deleting entire lessons or units, and nearly a quarter said they skipped or shortened the final project (Exhibit 8). Only about 3 in 10 CoolThink teachers reported that they did not make any modifications to individual CoolThink lessons.

Exhibit 8. Most CoolThink teachers reported modifying CoolThink courses and individual CoolThink lessons



Sample: *Course modifications n = 504, Lesson modifications n = 493.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

An unintended consequence of these common modifications is they may change some of the core elements of CoolThink@JC's intended design, which may potentially reduce a course's impact. CoolThink teacher interviews help to explain how and why teachers modified CoolThink course sequences and lesson materials. Some teachers rearranged activities or units in ways they believed would support greater conceptual understanding in the context of their classrooms.

> **The Magic Changing and Snowflake modules require more logical thinking, making it better to place them after the basic training. I assign the final project during the Easter holiday, which allows students sufficient time to work on it. This also enables me to review their individual abilities, helping me tailor my teaching approach and providing appropriate scaffolding. While CoolThink suggests putting the final project after completing all the modules, I find it more beneficial for students to learn computational thinking during the project itself. As the project is problem-based, they have to solve a problem and think of solutions independently.**
>
> **– CoolThink teacher**

However, interviewed teachers most frequently described modifications that streamlined or simplified content to make it more accessible to students. Most interviewed teachers described adaptations intended to provide more scaffolding for struggling students. These adaptations included more teacher explanation, help for struggling students from more advanced students, coding snippets to allow students who were falling behind to catch up with the rest of the class, and templates or extra scaffolding for struggling students.

> **We also review the provided templates to ensure they align with our students' progress. If necessary, we make adjustments by removing a few elements from the finished version, simplifying the coding process for the students.**
>
> **– CoolThink teacher**

> **Due to time constraints, we had to skip two modules (gold-finding and audio) in App Inventor and only briefly talk about them. We devoted more time to the final project, and I discussed with other teachers to prioritize modules that are more helpful for the project.**
>
> **– CoolThink teacher**

Teacher interviews and observations offered examples of the kinds of trade-offs that teachers made, with teachers of higher-ability students having more flexibility in their instructional decision-making.

One teacher with high-ability students prioritized coding and reflection as he allocated lesson time. When coding, the teacher said, students debug and learn how to solve problems. He said that during coding, **"students keep encountering issues and doing testing to make sure things work. This is like real life, where you constantly face different situations that you need to work through."** The teacher said he dedicated significant lesson time for students to reflect as well, because **"reflect is the most essential piece of learning not only in the classroom, but in the workplace as well."**

Teachers in lower-ability classrooms were more likely to modify CoolThink course materials in potentially unproductive ways.

As noted above, teachers in lower-ability CoolThink classrooms tended to give CoolThink course materials lower ratings for their accessibility and fit, and they reported greater time pressures. Unsurprisingly, teachers in lower-ability classrooms were more likely to simplify activities so that their students could complete them, often removing some unstructured time for exploration (see Appendix C, Exhibit C13). Conversely, teachers in higher-ability classrooms were more likely to report potentially productive modifications that scaffold tasks to allow more focus on exploration and problem-solving. For example, they were more likely to adopt a flipped classroom approach (27% of teachers of high-ability classrooms vs. 17% of lower-ability classrooms). Although relatively few teachers overall supplemented CoolThink courses with additional lessons and activities from the CoolThink co-curricular materials (only 5%–6% of CoolThink teachers reported using these materials in their classes), these kinds of modifications, designed to provide students with the opportunity to undertake a wider array of more challenging projects, were more common in lessons logged by teachers of higher-ability classrooms.

Teachers reported that MIT App Inventor courses were difficult for students at all ability levels. Teachers were more likely to simplify or streamline learning activities in App Inventor courses than in the Scratch course.

In the CoolThink course sequence, Level 1 (typically offered to Primary 4 students) uses the Scratch programming language, while Levels 2 and 3 (typically Primary 5 and 6 students) use MIT App Inventor. Because App Inventor is a more complex language that was originally developed for older students, it is not surprising that it offered more challenges for CoolThink's primary students.[2]

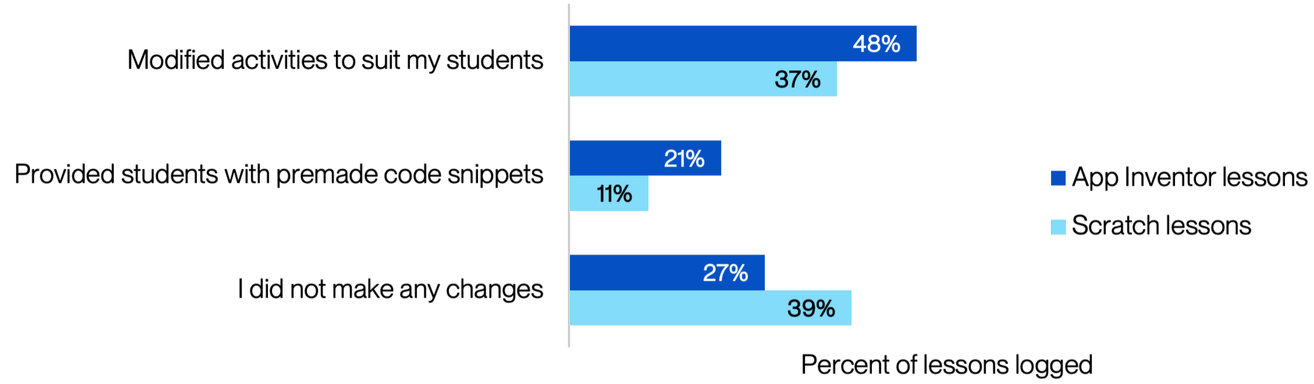
Across ability levels, MIT App Inventor teachers were less likely than Scratch teachers to agree that CoolThink@JC helps students develop deep conceptual understanding (rather than just complete programming tasks), solve open-ended problems, and exercise creativity in class. Specifically, 69% of App Inventor teachers agreed that CoolThink materials supported thorough conceptual understanding, compared with 82% of Scratch teachers (see Appendix C, Exhibit C14). App Inventor teachers also gave CoolThink materials lower ratings for accessibility and fit; for example, 33% of App Inventor teachers agreed that CoolThink materials were accessible for their lower-ability students, compared with 46% of Scratch teachers (see Appendix C, Exhibit C15). In addition, App Inventor teachers were far less likely to agree that the pacing of CoolThink materials was suitable for the majority of their students (48% of App Inventor teachers vs. 69% of Scratch teachers), suggesting that time pressures are particularly acute in the App Inventor courses and are especially so for App Inventor teachers in lower-ability classrooms.

Consistent with these findings, Level 2 and Level 3 App Inventor teachers were more likely to modify CoolThink courses than teachers who taught the Level 1 Scratch course only. On surveys, nearly half of App Inventor teachers reported that they skipped activities within lessons and that they modified activities to simplify them for students. App Inventor teachers were also more likely than Scratch teachers to report that

[2] For these reasons, the CoolThink-based sample curriculum units that have been developed by EDB as guidance for schools throughout Hong Kong use Scratch in both Primary 4 and Primary 5, and reserve App Inventor units for Primary 6 students.

they shortened or skipped the final project (see Appendix C, Exhibit C16). Similarly, on classroom logs, App Inventor teachers were more likely to report modifying activities to suit their students (48% of App Inventor lessons vs. 37% of Scratch lessons) and providing students with code snippets (21% of App Inventor lessons vs. 11% of Scratch lessons; Exhibit 9).

Exhibit 9. CoolThink teachers were more likely to modify MIT App Inventor lessons



Note: *All presented contrasts are statistically significant.*
Sample: *CoolThink classroom logs, App Inventor lessons n = 343, Scratch lessons n = 461.*
Source: *CoolThink classroom logs, 2022–23.*

In interviews, many teachers spoke to the challenges they experienced with implementing the MIT App Inventor courses. Some teachers even had trouble with the course content themselves, but their primary concern was with how difficult App Inventor was for most students at this age level. Comments from teachers and a student illustrate the difficulties students experienced:

> **Using App Inventor is challenging because it is more difficult than Scratch. Only the smarter students (20 out of 300 students) can handle it ... The other students are less engaged.**
>
> **– CoolThink lead teacher**

> **The App Inventor interface is difficult for students. Many students often need to spend a lot of time looking for suitable blocks to create the code.**
>
> **– CoolThink lead teacher**

> **I found that coding can be hard, and I lost confidence after learning App Inventor.**
>
> **– CoolThink student**

Teacher feedback on the difficulty of the App Inventor programming language for upper primary students suggests that the curriculum may not be optimized for these students, especially in lower-ability classrooms.

Instructional planning

Providing students with access to high-quality CoolThink instruction is key to helping them develop core skill sets such as computational thinking and design thinking. Given the time pressures reported by teachers across all classrooms, this implementation study examined the time teachers allocated to lessons, whether they integrated CoolThink@JC with other courses, and whether teachers used other ICT or computational thinking curriculum materials in addition to CoolThink@JC.

Most teachers report that CoolThink@JC requires more than the allocated 14 hours of total instructional time. They typically found the time by reducing the time devoted to traditional ICT topics and by integrating CoolThink lessons with ICT and other classes.

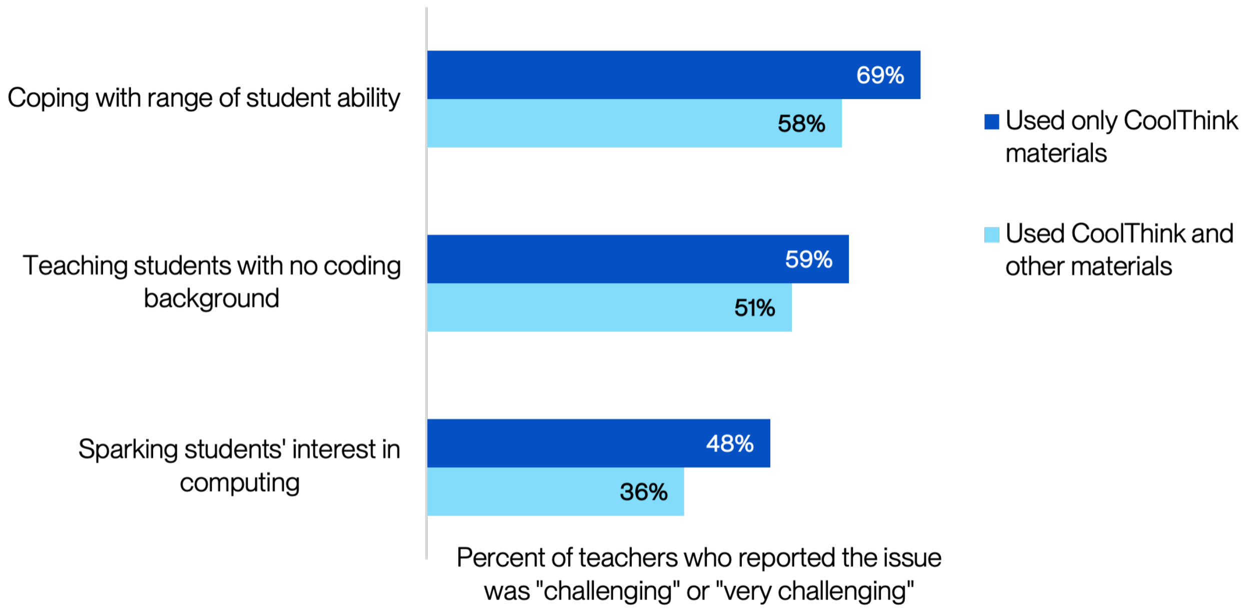
Consistent with prior years, in 2022–23 most teachers devoted more total time to CoolThink instruction than the 14 hours allocated in lesson materials. On average, CoolThink teachers spent 19 hours on CoolThink lessons for a given class of students, although the amount of time spent varied widely (see Appendix C, Exhibits C17–C19 for detail). Nearly 60% of teachers reported spending more than 14 hours on CoolThink instruction for any given class in 2022–23, and 30% reported spending more than 20 hours. When explaining why, teachers reported that in their experience, CoolThink lessons designed for a single 35-minute period generally took students longer than that to complete. Teachers also reported that they needed more time for students to work on projects independently and that it took more instructional time to attend to the needs of diverse learners.

School leaders reported that teachers made more time for CoolThink instruction by reducing the time available for other ICT topics. These schools planned their master schedule ahead of time to allocate more time for CoolThink courses, tilting the balance of available ICT instructional time further toward CoolThink. Although the majority of teachers (57% of 508 surveyed teachers) taught CoolThink@JC as a stand-alone course, some teachers also integrated CoolThink lessons into ICT (34%), general studies (7%), or science (2%) classes.

About half of CoolThink teachers use CoolThink@JC along with other curriculum materials to teach ICT, computational thinking, or coding. Teachers who teach both CoolThink and ICT lessons using other sets of curriculum materials appear to be more comfortable teaching CoolThink@JC.

Nearly all CoolThink teachers teach ICT as their primary (51%) or secondary (42%) teaching assignment. Of these teachers, nearly half reported using only CoolThink@JC for teaching ICT, computational thinking, or coding. Another 48% reported using mostly CoolThink materials, supplemented with other curriculum, including Silicon Workshop's Dr. PC Family (25% of teachers) and EDB's modular computer awareness program (19% of teachers). Teachers using CoolThink materials along with other curricula (i.e., teachers who likely spent more of their time teaching ICT, computational thinking, and coding than teachers who only used CoolThink materials) were more comfortable coping with a range of student abilities, teaching students with no coding background, and sparking students' interest in computing (Exhibit 10). These findings suggest that additional time spent on ICT instruction may benefit teachers as well as students.

Exhibit 10. Teachers who used CoolThink materials in combination with other ICT materials were more comfortable facing common instructional challenges



Note: *All presented contrasts are statistically significant, except teaching students with no coding background, which is marginally significant. For the full version of this exhibit including all item-level results, see Appendix C, Exhibit C20.*
Sample: *Cohort 3–5 follow-up, Used only CoolThink materials n = 227, Used CoolThink and other materials n = 270.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

CoolThink at the School Level

Key Findings

- Teacher confidence and self-reported readiness to teach CoolThink@JC were generally strong, with 79% expressing at least some confidence. These ratings were highest among teachers of the Level 1 Scratch course, and lowest for teachers in classrooms with more students performing below grade level.
- Teachers' background also makes an important difference: Teachers with an undergraduate degree in ITS or computer science reported substantially higher readiness and confidence than other teachers. Teachers with training in another STEM discipline reported slightly higher readiness and confidence than teachers with non-STEM degrees.
- CoolThink teacher development courses were a key contributor to teacher readiness and success in teaching CoolThink@JC. For many teachers, CoolThink courses were necessary but not sufficient; teachers benefited more by supplementing CoolThink courses with coaching and other professional development offerings.
- CoolThink school leaders believed strongly in the importance of CTE, and these beliefs have been sustained over time.
- School leader support matters: Teachers who reported that their school leader supports innovation were more likely to say that their students benefited from CoolThink@JC and less likely to report that teaching CoolThink@JC was challenging. Teachers in high-need schools and teachers of lower-ability classrooms were less likely to report that their school leader supports innovation.
- Most Cohort 1–2 schools continue to teach CoolThink courses at Primary 4–6 with only minor changes.
- Across cohorts, the most important factors in schools' decisions to adopt CoolThink@JC were the opportunity for teachers to participate in professional development and alignment between CoolThink curriculum and the school's instructional goals. Cohort 5 schools were more likely to report that EDB guidelines were an important factor.
- CoolThink schools' access to resources and support for adopting CoolThink@JC increased over baseline, as they gained experience with CoolThink@JC.

Key success factors for CoolThink@JC at the school level include teacher capacity, school leader support, and school readiness to adopt new 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, as are school leaders' beliefs about the value of CTE.

CoolThink teacher capacity

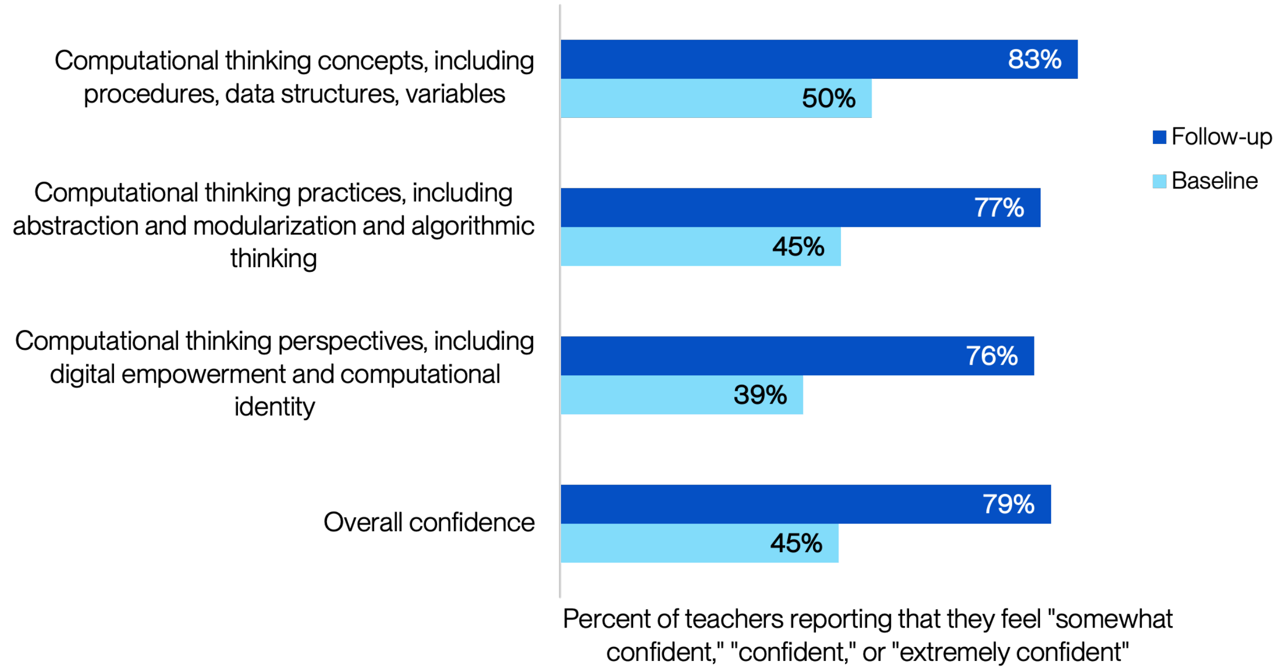
As CoolThink@JC continues to scale to more schools and more teachers, ongoing development of teacher capacity for computational thinking instruction is a key success factor. In this research, we characterize teacher capacity as confidence; preparedness and self-efficacy in teaching computational thinking concepts, practices, and perspectives; and productive beliefs about CoolThink@JC's ability to develop students' conceptual understanding. Interview data suggest that teachers' confidence and sense of preparedness contributed to stronger CoolThink@JC implementation. At scale, we can expect teacher capacity for computational thinking to vary based on teacher backgrounds, teaching assignments, student ability levels, the professional development that teachers receive, and the school leader support available for teachers. In this section, we briefly describe participating CoolThink teachers and their backgrounds, teaching assignments, and perceived student ability levels; then, we report how these factors were associated with teacher capacity for computational thinking instruction.

Nearly half of CoolThink teachers were experienced teachers with more than 10 years of teaching experience (see Appendix C, Exhibit C21). However, the majority of CoolThink teachers had limited experience teaching ICT (5 years or fewer; see Appendix C, Exhibit C22). Nearly half of CoolThink teachers completed undergraduate degrees in non-STEM fields (see Appendix C, Exhibit C23). About half of the CoolThink teachers taught ICT as their primary teaching assignment (see Appendix C, Exhibit C24).

CoolThink teachers' confidence in teaching computational thinking increased significantly over baseline, and after a year or more of experience, teachers generally felt well prepared to teach CoolThink lessons.

On surveys at the end of each school year, CoolThink teachers' confidence incorporating computational thinking concepts, practices, and perspectives in their teaching increased significantly relative to the months just before they began teaching CoolThink@JC (Exhibit 11); on average, the proportion of teachers expressing at some confidence teaching CoolThink rose from 45% at baseline to 79% after a year or more. Although teacher confidence increased on all three dimensions of computational thinking, teachers generally reported feeling more confident with computational thinking concepts than with practices and perspectives. More than half the CoolThink teachers agreed or strongly agreed they were prepared to teach CoolThink lessons and the computational thinking content in them, either in unplugged contexts or when using the Scratch and MIT App Inventor programming languages (see Appendix C, Exhibit C25).

Exhibit 11. Teacher confidence using computational thinking concepts, practices, and perspectives in their teaching increased compared to baseline



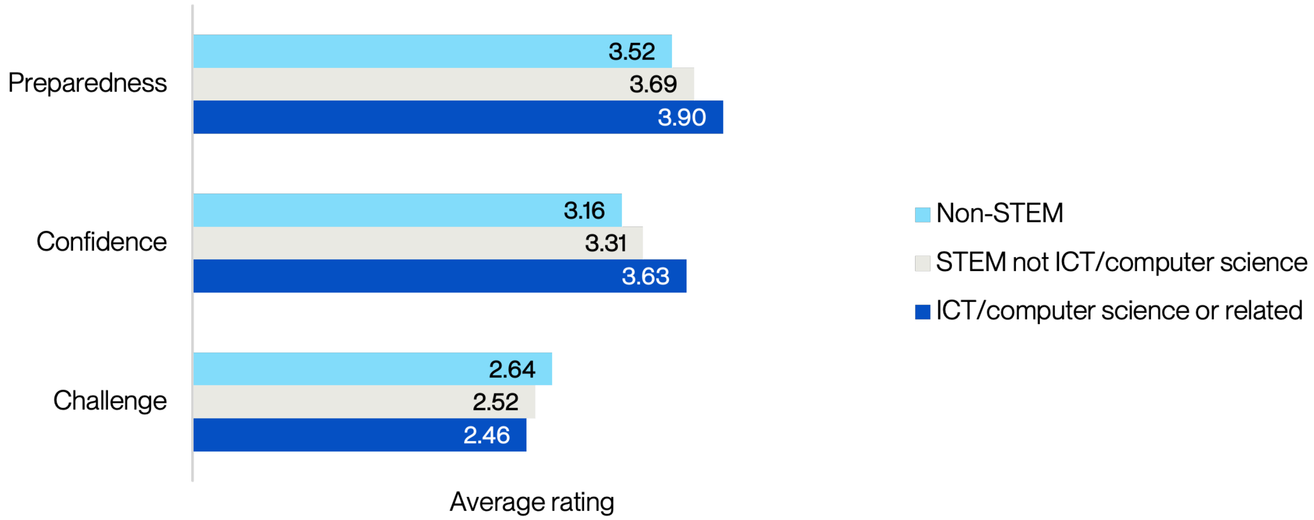
Note: *All presented contrasts are statistically significant. For the full version of this, see Appendix C, Exhibit C25.*
Sample: *n = 367. Sample restricted to teachers who responded at both baseline and follow-up.*
Source: *Cohort 3–5 baseline teacher survey (fall 2020, 2021, 2022) and Cohort 3–5 follow-up teacher survey (summer 2023).*

However, teacher confidence and preparedness varied widely based on teacher background, ICT teaching experience, type of CoolThink courses taught, instructional materials used, student ability levels, teacher professional development courses taken, and perceived school leader support. One key lesson from CoolThink@JC's scaling phase is the importance of identifying factors associated with lower teacher confidence and readiness so that those factors can be effectively targeted in future implementation efforts.

Teachers' undergraduate majors and teaching experience were associated with their capacity for teaching CoolThink@JC.

CoolThink teachers with undergraduate degrees in ICT or computer science reported feeling the most confident using computational thinking as part of their teaching, feeling the most prepared to teach CoolThink@JC, and experiencing the fewest challenges with teaching CoolThink@JC, compared with other teachers. Teachers who majored in STEM fields but not in ICT or computer science had lower capacity for teaching computational thinking, and teachers with non-STEM degrees felt least confident and prepared and found teaching CoolThink@JC to be the most challenging (Exhibit 12).

Exhibit 12. Teachers with non-STEM undergraduate degrees reported feeling the least prepared and confident and perceived the most challenges with teaching CoolThink



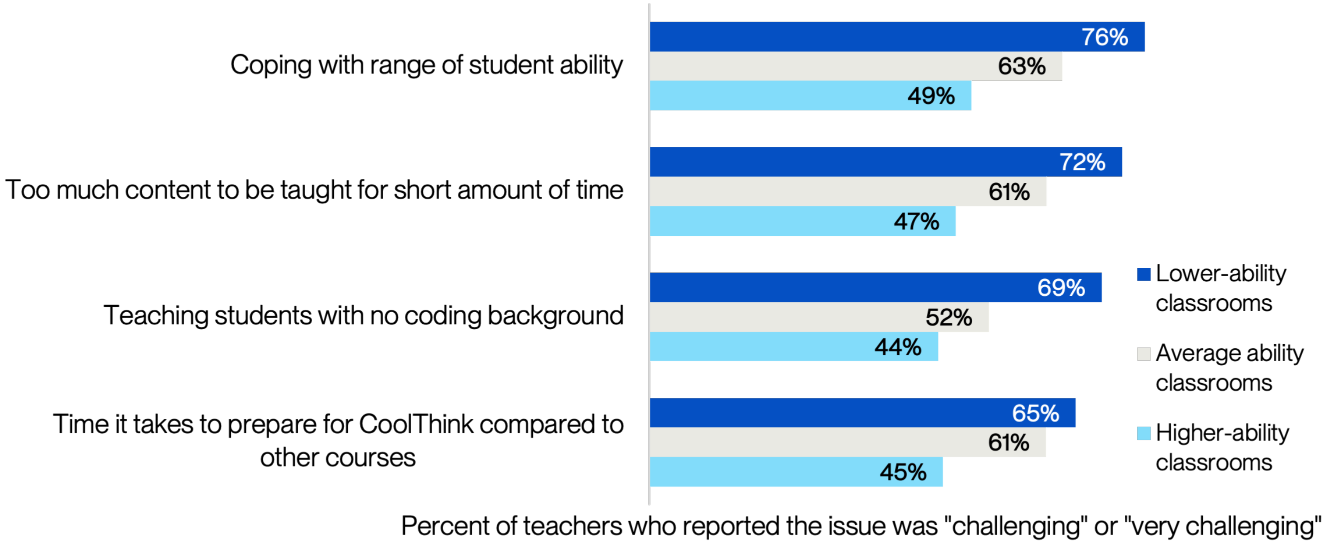
Note: *Preparedness is the average of 10 survey items about how prepared teachers felt to teach CoolThink@JC. Items were rated on a scale from 1 (strongly disagree) to 5 (strongly agree). Confidence is the average of three survey items about teachers' confidence with computational thinking concepts, practices, and perspectives. These items were rated on a scale from 1 (not at all confident) to 5 (extremely confident). Challenge is the average of 9 survey items about the challenges teachers faced when using CoolThink course materials with their students. Items were rated on a scale from 1 (not at all challenging) to 4 (very challenging). All presented contrasts are statistically significant. For the full version of this exhibit including all item-level results, see Appendix C, Exhibits C27–C29.*
Sample: *Cohort 3–5 follow-up, Non-STEM n = 194, STEM not ICT/computer science n = 138, ICT/computer science or related n = 99.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

The same patterns held true for teachers with 5 or fewer years of ICT teaching experience: They felt significantly less confident than teachers with more than 5 years of ICT teaching experience, especially with computational thinking practices and perspectives; felt less prepared to teach CoolThink@JC; and were more likely to report challenges teaching CoolThink@JC.

Teacher confidence and sense of efficacy in teaching CoolThink@JC was lower in lower-ability classrooms.

Teachers in lower-ability classrooms felt significantly less confident teaching computational thinking concepts, practices, and perspectives and less prepared to teach CoolThink@JC, compared with teachers of higher-ability students (Appendix C, Exhibit C30–31). Teachers in lower-ability classrooms also considered CoolThink@JC significantly more challenging to teach, compared with other teachers (Exhibit 13). These data are consistent with earlier descriptions of teachers in lower-ability classrooms being less likely to agree that CoolThink@JC helps students develop deep conceptual understanding and that students can transfer skills from CoolThink@JC to other contexts (see Exhibit 7), or that their students had benefited from CoolThink lessons in other ways.

Exhibit 13. Teachers in lower-ability classrooms found CoolThink significantly more challenging to teach



Note: *All presented contrasts are statistically significant. For the full version of this exhibit, see Appendix C, Exhibit C32.*
Sample: *Cohort 3–5 follow-up, Higher-ability classrooms n = 127, Average-ability classrooms n = 216, Lower-ability classrooms n = 152.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

Scratch teachers reported being better prepared to teach CoolThink@JC, had greater confidence, and were less likely to perceive challenges than MIT App Inventor teachers.

Most Scratch teachers (80%) felt prepared to teach Scratch, whereas only half of App Inventor teachers (54%) felt prepared to teach App Inventor. Teachers found it significantly more challenging to teach students without any prior coding background when they only taught courses using the more advanced App Inventor programming language, compared with when they taught courses using the Scratch programming language. Also, as noted earlier, teachers teaching App Inventor were less likely to agree that CoolThink@JC helps students develop deep conceptual understanding and problem-solving skills and that students can transfer skills from CoolThink@JC to other contexts.

CoolThink teacher development

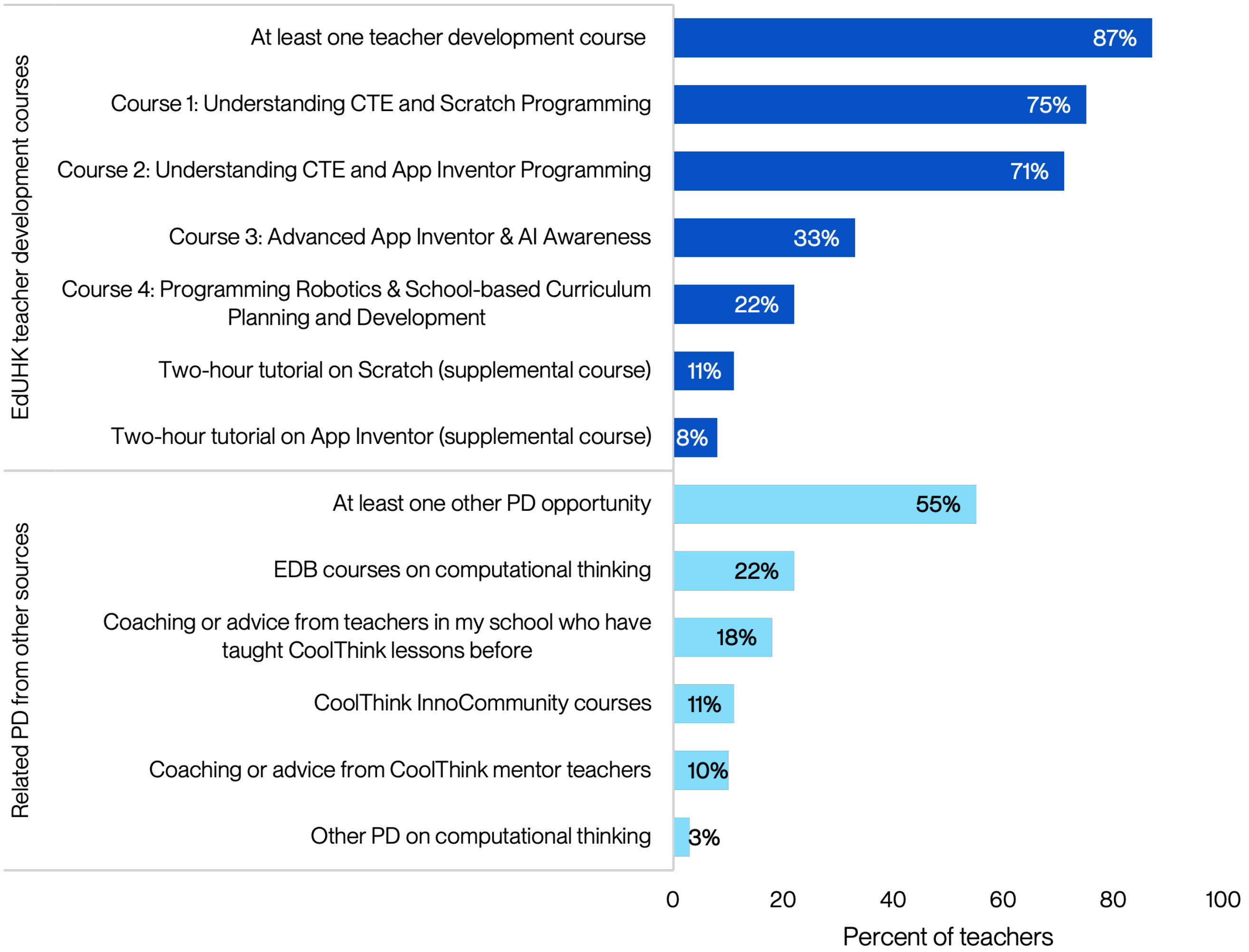
Teacher confidence incorporating CTE concepts, practices, and perspectives has increased over baseline in part because of their participation in CoolThink professional development, both the teacher development courses provided by EdUHK and the support provided by CoolThink mentor teachers.

Throughout CoolThink@JC's scaling phase, CoolThink teacher development courses were the most important source of training for CoolThink teachers; participating in coaching and mentoring activities was more limited.

The CoolThink teacher development courses offered by EdUHK remained the most important source of professional development for teachers in the CoolThink network throughout the initiative's scaling phase.

By 2022–23, nearly all Cohort 3–5 teachers (87%) had participated in least one 12-hour CoolThink teacher development course during their school's participation in the network (Exhibit 14): 75% had completed Course 1: Understanding CTE and Scratch Programming, and 71% had completed Course 2: Understanding CTE and App Inventor Programming. A third of teachers completed the course on Advanced App Inventor & AI Awareness, and about a fifth (22%) completed the course on Programming Robotics & School-based Curriculum Planning and Development. About 11% of teachers completed the 2-hour supplemental tutorials for Scratch and App Inventor.

Exhibit 14. Most CoolThink teachers had completed at least one CoolThink teacher development course by the end of the scaling period; participation in coaching and mentoring activities was much more limited



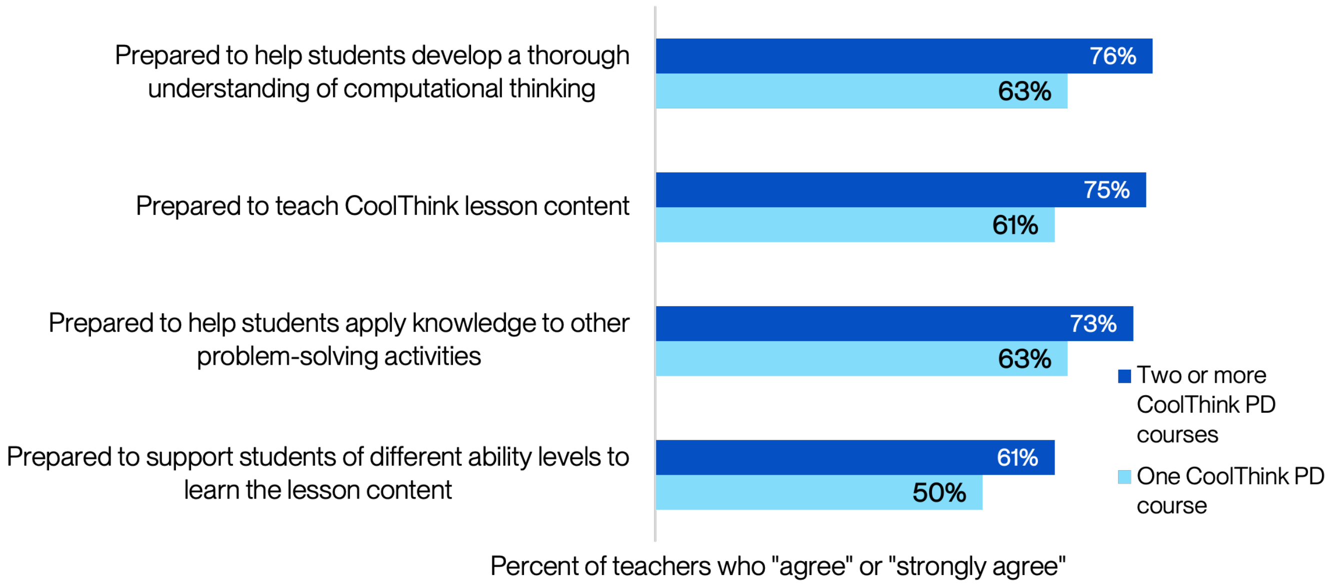
Note: *The summer 2023 survey asked about any teacher development courses completed since the beginning of the 2020–21 school year. We supplemented 2023 responses with responses on the 2021 and 2022 surveys where available.*
Sample: *n = 505 for question about EdUHK teacher development courses. n = 472 for question about PD from other sources.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

In total, about half of teachers (55%) reported they participated in related professional development from another source in 2022–23 (e.g., an EDB or InnoCommunity workshop, or coaching or mentoring for teachers at their school). CoolThink teachers' participation in coaching and mentoring activities was relatively limited, with about a fifth of teachers reporting that they had received coaching or advice from a teacher in their school, and just 1 in 10 reporting that they had received coaching or advice from a CoolThink mentor teacher.

Most teachers who took CoolThink teacher development courses felt well prepared to teach CoolThink, especially when teachers took multiple courses or combined the courses with other forms of professional development.

Teachers who took two or more CoolThink teacher development courses felt significantly more prepared to teach CoolThink@JC compared with teachers who took one or no courses (Exhibit 15).

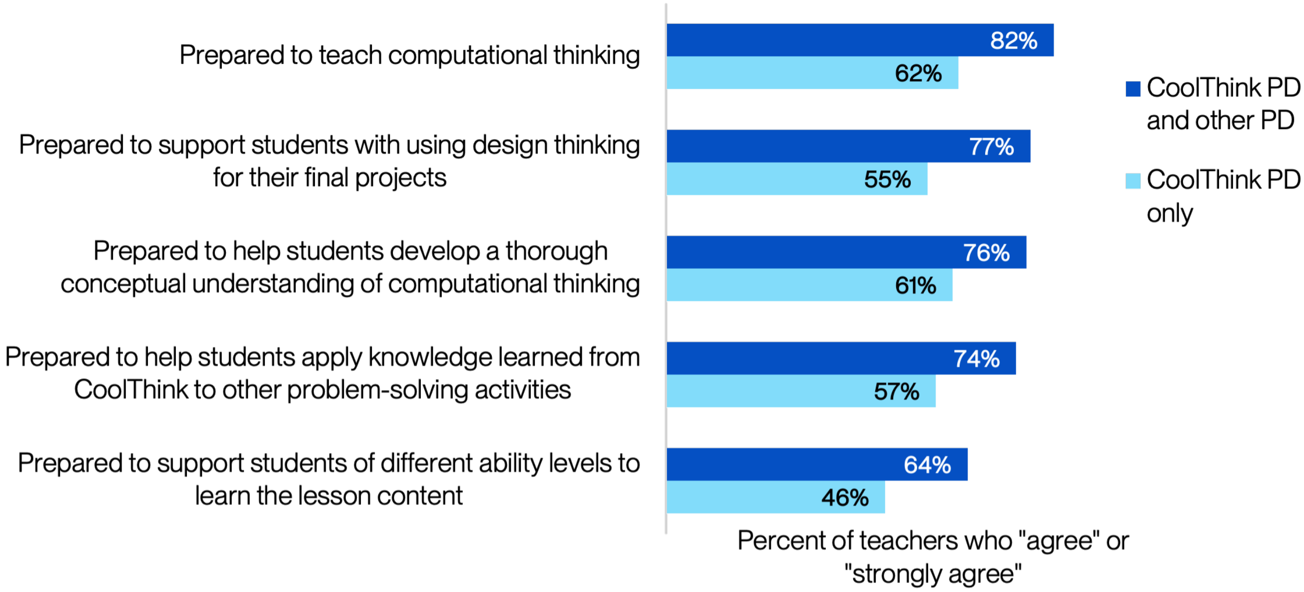
Exhibit 15. Teacher preparedness to teach CoolThink is higher for teachers who take multiple CoolThink teacher development courses



Note: *All presented contrasts are statistically significant. For the full version of this exhibit including all item-level results, see Appendix C, Exhibit C33.*
Sample: *Cohort 3–5 follow-up, Two or more CoolThink PD courses n = 236, One CoolThink PD course n = 169.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

CoolThink teacher development courses were particularly effective when supplemented with activities such as coaching and collaboration within school-based teams. Teachers who participated in other coaching or professional development in addition to CoolThink teacher development felt significantly more prepared to be a CoolThink teacher compared with those who only participated in CoolThink teacher development (Exhibit 16).

Exhibit 16. Teacher preparedness to teach CoolThink was significantly higher when teachers supplemented CoolThink teacher development with other professional development



Note: *All presented contrasts are statistically significant. For the full version of this exhibit including all item-level results, see Appendix C, Exhibit C34.*
Sample: *Cohort 3–5 follow-up, CoolThink PD and other PD n = 407, CoolThink PD only n = 58.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

In interviews, teachers mentioned a range of different supports that were important to help them feel prepared to teach CoolThink@JC. Of these, the most commonly mentioned were the CoolThink teacher development courses.

> **The professional development course not only taught us the concepts and how to code, but also addressed common difficulties faced by students, so that we could prepare before the lesson.**
>
> **– CoolThink teacher**

> **We receive support through class observation from the CoolThink team at EdUHK and technical assistance. Among all these supports, teacher training was the most important. The teachers who are going to teach those modules attend the training, and it proved to be useful and practical. Additionally, Zoom lessons are okay, because sometimes I am busy.**
>
> **– CoolThink teacher**

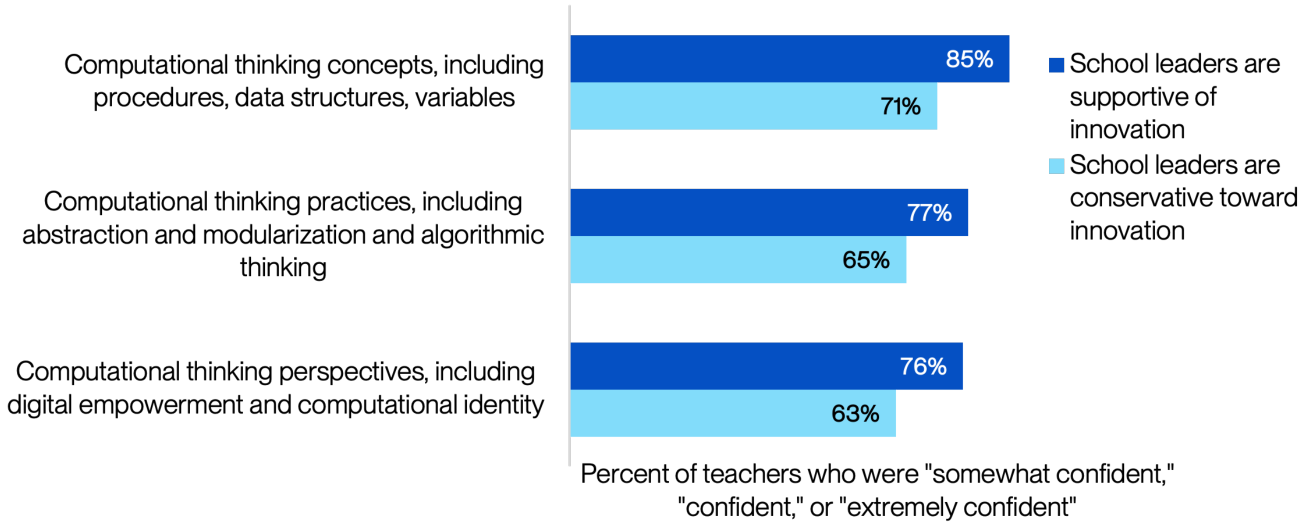
School leader support for innovation

Most CoolThink teachers (73%) considered their school leaders to be supportive of innovation, new ideas, and new methods, and only 27% considered their school leaders to be conservative toward innovation. Teachers of lower-ability classrooms were less likely to report that their school leader supports innovation.

Teachers' perceptions of school leader support for innovation are a key predictor of teacher capacity and student access to high-quality CoolThink instruction.

Teachers who considered their school leaders to be conservative toward innovation felt significantly less confident teaching computational thinking concepts, practices, and perspectives (Exhibit 17). These teachers were also less likely to agree that CoolThink@JC helps develop deep conceptual understanding and problem-solving skills and that students can transfer skills from CoolThink@JC to other contexts. Further, teachers who did not consider their school leaders to be supportive of innovation were more likely to consider CoolThink lessons challenging to teach and less likely to consider CoolThink materials to be understandable for themselves and accessible for their students. These teachers also reported lower levels of student enthusiasm, effort, and interest.

Exhibit 17. Teacher confidence teaching computational thinking was lower when teachers perceived school leader support to be lacking



Note: *All presented contrasts are statistically significant. For the full version of this exhibit, see Appendix C, Exhibit C35.*
Sample: *Cohort 3–5 follow-up, School leaders are supportive of innovation n = 357, School leaders are conservative toward innovation n = 128.*
Source: *Cohort 3–5 follow-up teacher survey (summer 2023).*

As described earlier, teachers in lower-ability classrooms reported similar patterns of confidence and more negative judgements about the accessibility of CoolThink materials for their students. These teachers were also less likely to report strong school leader support for innovation—a commonplace pattern in settings where basic academic performance is a target for focus and improvement. Both of these factors likely contributed to the additional challenges often experienced as teachers in lower-ability classrooms adopt innovative curricula such as CoolThink@JC. These findings point again to the need for both curricula and implementation to be designed in ways that are easy to adapt to these settings.

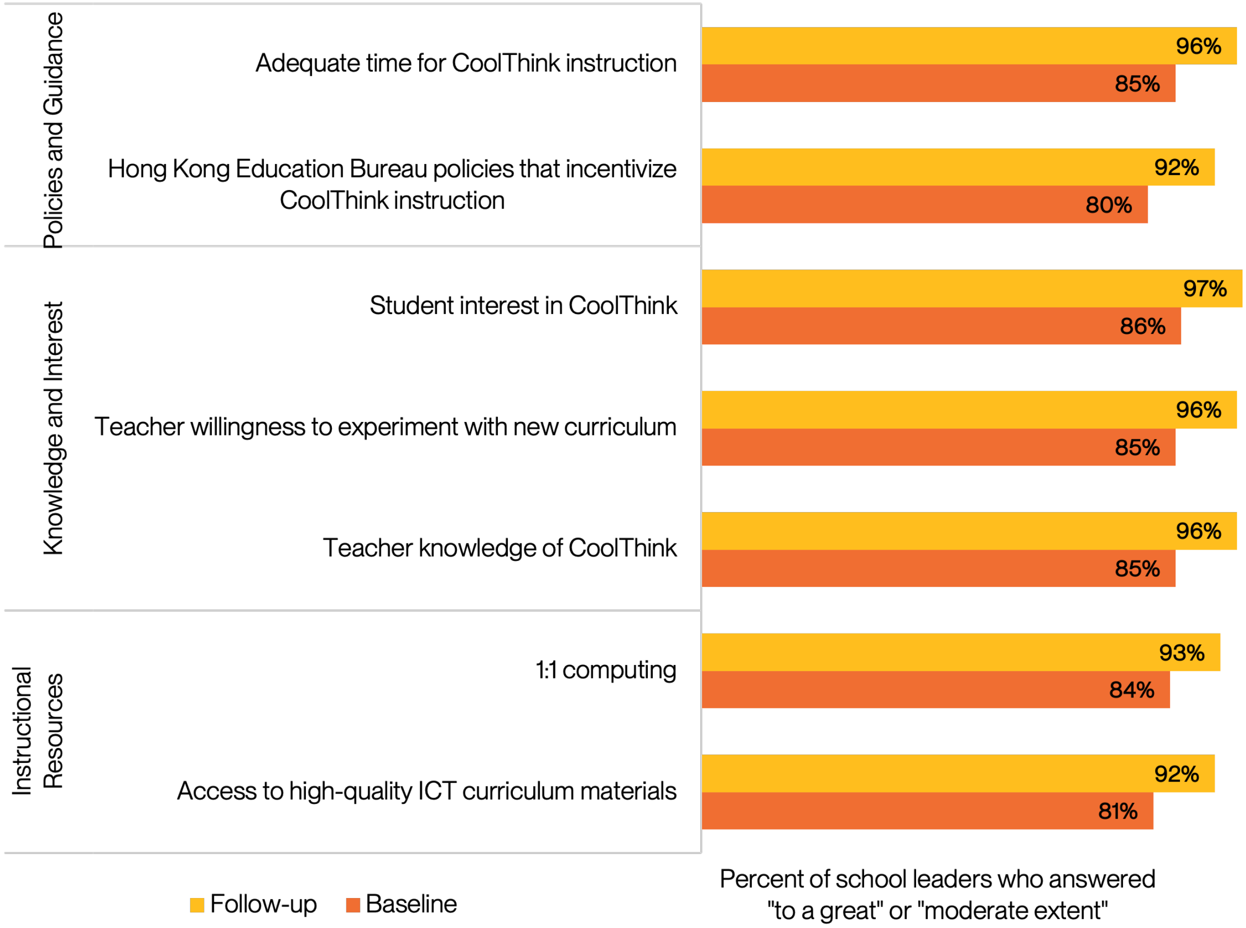
School readiness to sustain CoolThink@JC

As CoolThink@JC scales across different cohorts, readiness to sustain the program is demonstrated by school-level resources, knowledge and interest from stakeholders, and existing policies supporting ICT instruction. Different stages of implementation may impact the type and level of support available for each cohort. Compared with baseline results, school leaders in the scaling phase were more likely to report that resources are in place at follow-up. Cohort 3 school leaders reported the largest increase in resources available, indicating that schools' capacity-building may expand with time and experience.

Schools' readiness to adopt and sustain CoolThink@JC increased over time, as they gained experience with the program.

Across Cohorts 3–5, a higher percentage of school leaders reported that their schools had access to resources and support for CoolThink@JC implementation at follow-up, compared with baseline (Exhibit 18). The most significant growth from baseline was in the leaders' reports of student interest, teacher knowledge, and teacher willingness to try new curriculum. This growth may indicate increased buy-in from students and teachers as schools gain experience with CoolThink@JC. In addition, internal resources and external conditions are associated with readiness to sustain CoolThink@JC. For example, school leaders were more likely to report that the school had access to adequate time for CoolThink instruction, high-quality curriculum materials, and one-to-one computing at follow-up. Similarly, EDB policies and support from the school sponsoring bodies (SSBs) were reported at a higher percentage, compared with baseline.

Exhibit 18. School leaders reported more resources available at follow-up than baseline



Note: *All presented contrasts are statistically significant. For the full version of this exhibit, see Appendix C, Exhibit C36.*
Sample: *Cohort 3–5 n = 75. Sample restricted to school leaders who responded at both baseline and follow-up.*
Source: *Cohort 3–5 baseline school leader survey (fall 2020, 2021, 2022) and Cohort 3–5 follow-up school leader survey (summer 2023).*

As schools progress in their implementation of CoolThink@JC, variations emerge among the three cohorts in school leaders' assessments of resources available to support the program. Cohort 3 school leaders' appraisal of the resources were the most positive, followed by Cohort 4 and Cohort 5, respectively. These differences suggest that schools' capacity to support and sustain CoolThink instruction grows over time. In Cohort 3, significantly more school leaders named student interest, teacher knowledge, access to high-quality curriculum, and EDB policies as resources available 3 years after the start of implementation. In Cohort 4, school leaders were more likely to respond that resources such as adequate time for CoolThink instruction, teacher willingness to try new curriculum, and relevant EDB policies are accessible at follow-up. Likewise, more Cohort 5 school leaders reported teacher willingness to try new curriculum, compared with baseline. These results illustrate the different resources schools may have in place at different stages of implementation, ranging from classroom-level engagement to school-level and municipal-level support over time. The results also reflect the CoolThink team's progress in supporting new EDB policies related to computational thinking over the course of the initiative, including an enriched coding requirement, as we will describe in the section on CoolThink at the system level.

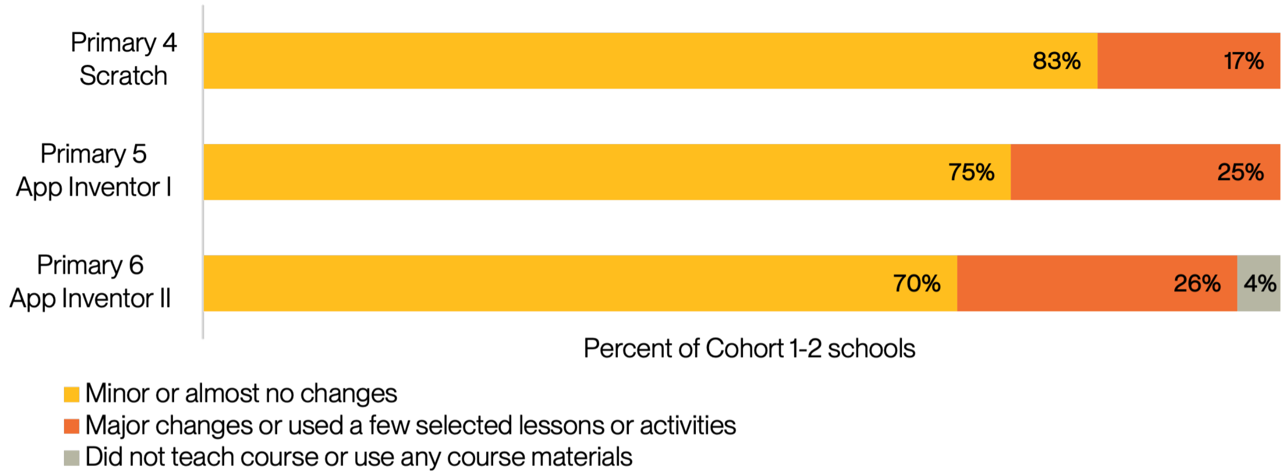
Sustaining CoolThink in Cohort 1–2 schools

A key indicator of CoolThink@JC's long-term sustainability involves looking at implementation outcomes in pilot-phase schools after direct support has ended. Successful scaling of the program over time can be characterized by curriculum fidelity, staffing and scheduling, and perception of benefits for stakeholders. Responses from school leaders show that most Cohort 1–2 schools continued to teach the three CoolThink courses with only minor changes and prioritized scheduling to provide ample hours for instruction. Almost all Cohort 1–2 schools also continued to assign new teachers to teach CoolThink@JC and provided internal support through more experienced CoolThink teachers and school-based teams. Pilot-phase school leaders widely reported benefit from CoolThink@JC that they perceived for students and teachers, an important indication of sustainability; however, those reports of benefit were somewhat more measured than those of scaling-phase school leaders.

More than 7 years after first adopting CoolThink materials, most Cohort 1 and 2 schools reported they were still teaching CoolThink courses.

Across Primary 4–6, schools reported teaching CoolThink courses as designed or with only minor changes (Exhibit 19). Schools were also teaching CoolThink@JC in the intended three-course sequence, with most school leaders reporting that Scratch, App Inventor I, and App Inventor II were taught in Primary 4, 5, and 6, respectively. For example, more than 80% of schools responded that they were teaching Scratch with minor or no changes in Primary 4, while the rest reported teaching the course with major changes or using only a few select lessons and activities. Interestingly, about a third of the responses indicate that schools were also teaching App Inventor I and II in Primary 4, suggesting that some schools may be offering additional CoolThink courses in Primary 4. In Primary 5–6, around three quarters (70%–75%) of school leaders reported that their schools taught App Inventor I and II, respectively, with few or no changes to the course design.

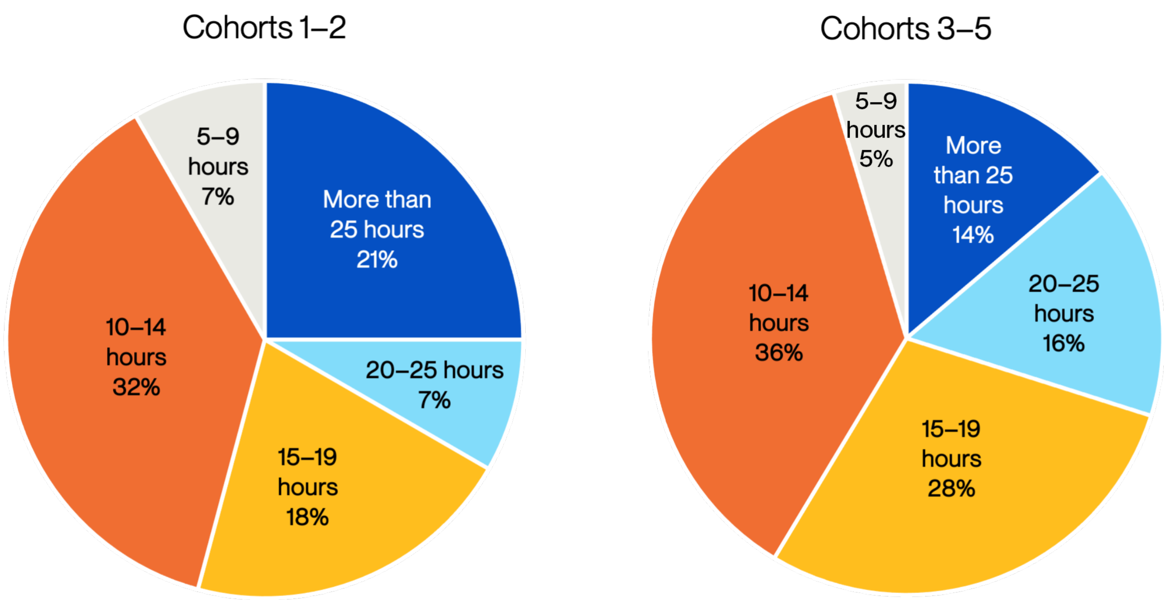
Exhibit 19. Most Cohort 1–2 schools continued to teach CoolThink courses with few or no changes



Sample: *Cohort 1–2 n = 24.*
Source: *Cohort 1–2 follow-up school leader survey (summer 2023).*

As in the scaling-phase schools, most Cohort 1–2 school leaders reported that CoolThink lessons required more than the 14 hours of instructional time that is recommended both by CoolThink@JC and in EDB policy. On average, Cohort 1–2 teachers reported spending 19 hours on CoolThink instruction annually for a given class of students, the same as their counterparts in Cohorts 3–5. Like Cohort 3–5 schools, more than a quarter of Cohort 1–2 schools spent well over this average for each class of CoolThink students (25 hours or more; Exhibit 20). More than 90% of Cohort 1–2 school leaders reported that they were able to find this extra time for CoolThink instruction, either by planning the master schedule in advance or by allocating less instructional time for other ICT lessons. This suggests that, like their counterparts in Cohorts 3–5, school leaders in many pilot-phase schools value CoolThink@JC enough to continue to prioritize it even though it is no longer a requirement for them to do so, and to create school conditions that support successful CoolThink instruction in the long term.

Exhibit 20. More than 1 in 4 Cohort 1–2 schools allocated more than 25 hours to CoolThink instruction each year, like schools in the later cohorts

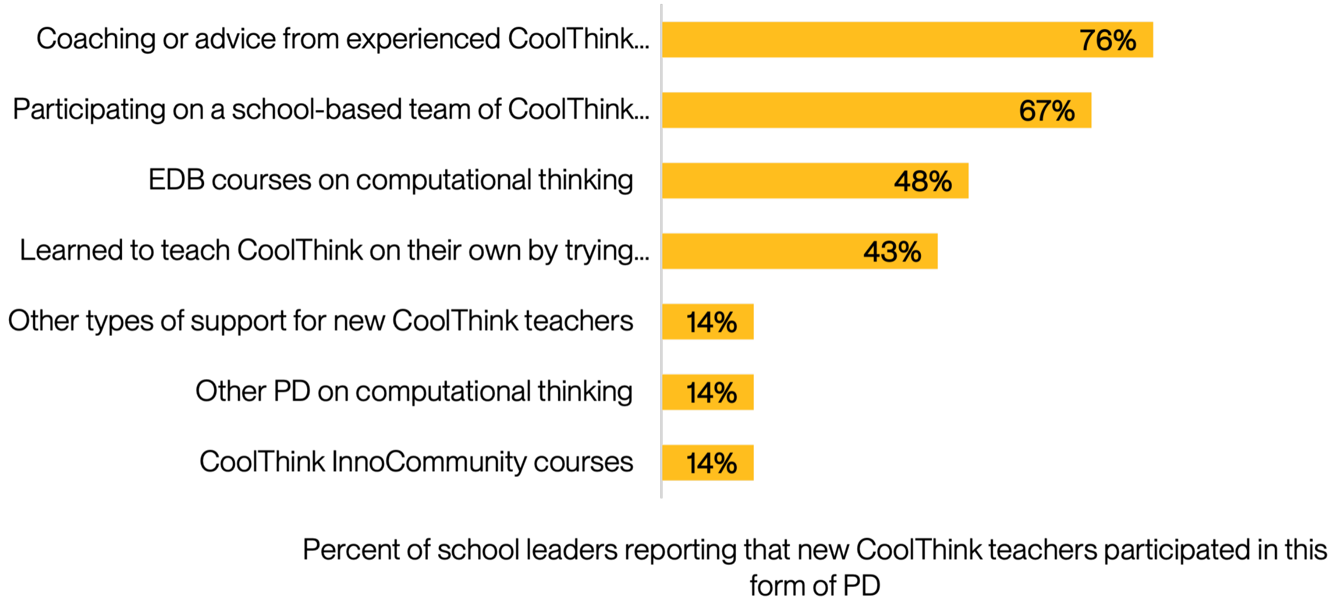


Sample: *Cohort 1–2 n = 24, Cohort 3–5 n = 88.*
Source: *Cohort 1–2 follow-up school leader survey, Cohort 3–5 follow-up school leader survey (summer 2023).*

Among pilot-phase schools, school-based teams of experienced CoolThink teachers were an important resource for training new teachers and sustaining teacher capacity to teach CoolThink@JC.

Since the end of the pilot phase in spring 2020, almost all Cohort 1–2 schools had added at least 1–3 new CoolThink teachers. Notably, a significant percentage of these schools had added more than 10 new CoolThink teachers within the previous 3 years, demonstrating that the pilot-phase schools have been able to continue to grow CoolThink instructional capacity even after direct support has ended. Further, many Cohort 1–2 schools utilized internal resources to train new CoolThink teachers who did not have the opportunity to attend CoolThink teacher development courses offered by EdUHK during the pilot phase. The most common types of support for new CoolThink teachers included coaching or advice from experienced CoolThink teachers and co-planning with a school-based team of CoolThink teachers (Exhibit 21). Other sources of training included attending EDB courses on computational thinking and independent learning of CoolThink@JC by trying it out in classrooms.

Exhibit 21. Main sources of support for new CoolThink teachers came from experienced CoolThink teachers and school-based teams

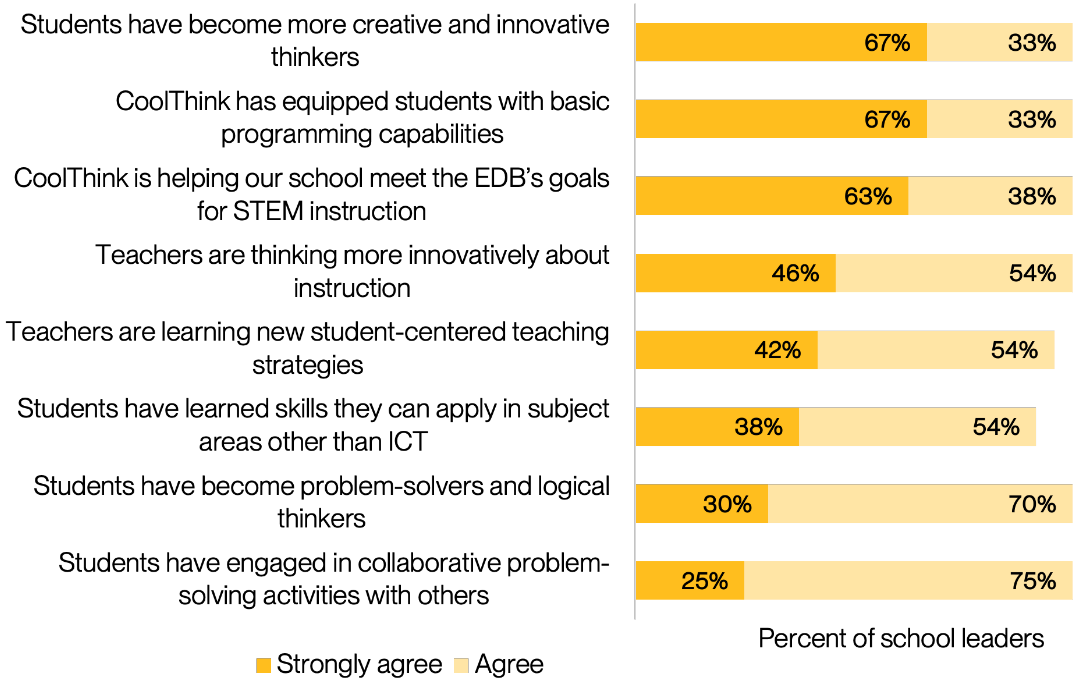


Sample: *Cohort 1–2 n = 24.*
Source: *Cohort 1–2 follow-up school leader survey (summer 2023).*

Even several years after their active involvement in the CoolThink initiative, school leaders in pilot cohorts strongly endorsed the benefits of CoolThink@JC for both students and teachers.

Nearly all school leaders in Cohort 1 and 2 schools reported that CoolThink had benefited both their teachers and students in multiple ways. In some key areas aligned with the creators' goals for CoolThink@JC, pilot school leaders strongly endorsed the program's benefits: For example, the majority strongly agreed that students had become more creative and innovative thinkers, that students had learned basic programming skills, and that CoolThink was helping their school meet goals for STEM education (Exhibit 22). Nearly half of pilot-phase school leaders also strongly agreed that teachers were thinking more innovatively about instruction and had learned new student-centered teaching strategies.

Exhibit 22. School leaders in more recent cohorts were more likely to agree strongly that CoolThink benefits teachers and their school



Sample: *Cohort 1–2 n = 24.*
Source: *Cohort 1–2 follow-up school leader survey (summer 2023).*

Cohort 3–5 school leaders were somewhat more tempered in their assessment of CoolThink's benefits for teachers and students. For example, while two thirds of pilot-phase school leaders strongly agreed that CoolThink@JC had helped their students become more creative and move innovative thinkers, only a third of Cohort 3–5 school leaders reported the same strong level of agreement (see Appendix C, Exhibit C37). Similarly, while nearly half of pilot-phase school leaders strongly agreed that CoolThink@JC had helped teachers think more innovatively about instruction, about a quarter of Cohort 3–5 school leaders reported the same. It is important to note that Cohort 1–2 schools were very early adopters, and only the Cohort 1–2 schools that responded to these questions on the school leader survey were those that reported they were still using CoolThink materials. However, because so many pilot-phase schools have sustained their use of CoolThink@JC, it is equally possible that perceptions of the program's benefits tend to improve the longer a school engages with the program.

Across all five cohorts, school leaders strongly believed in the importance and benefits of CTE for upper primary grades (see Appendix C, Exhibit C38). Every school leader agreed that CTE should be incorporated into the regular school schedule for Primary 4–6 students, and almost all school leaders strongly agreed that CTE fostered soft skills such as problem-solving, creativity, collaboration, and communication.

CoolThink at the System Level

Key Findings

- CoolThink@JC is supported by an extensive network of organizations across the CTE system in Hong Kong.
- The enriched coding education requirement is a major milestone to embedding CTE and AI concepts into Hong Kong's education curriculum.
- A constellation of initiatives and programs build public awareness of the value of computational thinking.
- Teachers are a critical component of the CoolThink@JC ecosystem and are supported by an array of professional supports to build their skill and confidence in computational thinking.
- CoolThink@JC has been a driving factor in promoting community recognition of the importance of computational thinking for students' future success.
- Ongoing challenges to sustaining CoolThink@JC include the needs for ongoing funding, continuing to expand the network of supports as CoolThink@JC continues to scale, and making sure that development opportunities and other supports help teachers continue to navigate the transition from teaching students how to code to teaching them the concepts and practices of computational thinking.

An organizational ecosystem refers to the network of interconnected organizations, processes, policies, and beliefs that supports the implementation of a program. For CoolThink@JC, the development of a sustainable, territory-wide ecosystem to support CTE is the culmination of The Trust's varied efforts to put these factors in place and will be a key enabler of CoolThink@JC's long-term sustainability. As The Trust prepares to transfer leadership of CoolThink@JC's implementation to the CoolThink teachers' association—the Association of Computational Thinking InnoCommunity Teachers (ACTIT)—this report describes how deeply the program has been integrated into the organizational systems that advance computational thinking within the territory to ensure a smooth transition and attain long-term success.

To understand accomplishments toward the development of the ecosystem, we interviewed 12 system-level actors across CoolThink@JC's governing bodies. These system-level actors included representatives from government, education, and professional organizations, as well as industry. The section below describes, through the eyes of those actors, each of the key components of the ecosystem supporting CoolThink scaling and CTE more broadly, including the vision for CoolThink@JC, its governance structure, the activities conducted to support the scale and sustainability of CoolThink@JC, ongoing challenges, and the future vision for the program. Findings are aligned with CoolThink@JC's system-level success factors (see Exhibit 2), including CoolThink governance, policy contexts, public awareness, and teacher network.

CoolThink@JC governance structure

A key goal of CoolThink@JC is to increase equitable access to high-quality CTE for all Hong Kong students and bridge the digital divide in basic digital literacy and problem-solving skills.

This is a challenging and ambitious goal, and often organizations aiming for broad reach and impact find they are able to engage only a finite number of partners, making it difficult to achieve the desired reach. However, CoolThink@JC's extensive outreach efforts have resulted in widespread access to students. Since its inception, the program has reached more than 100,000 students (The Hong Kong Jockey Club Charities Trust, 2024).

> **I think [the] student is also a key element in our initiatives … we hope students enjoy the computational thinking and the coding education very, very much. … That is what education is for. Learning is fun.**
>
> **– System-level actor**

To this end, the CoolThink@JC governance structure, described in detail below, can serve as a model for other initiatives to emulate.

CoolThink@JC is supported by an extensive network of organizations across the CTE system. The Trust plays a critical role in convening partners and leading engagement activities.

To achieve CoolThink@JC's goals, the governance structure includes an Advisory Committee; an Expert Group; three subcommittees to promote adoption and capacity-building, awareness, and enabling tools and platform-building; and a Consultative Group. The Trust plays a critical role in the ongoing growth and support of CoolThink@JC and is responsible for leading all facets of governance, in partnership with supporting organizations. Exhibit 23 shows the Trust as the backbone organization, bringing together a wide array of organizations and champions of CoolThink@JC.

Participants in the CoolThink@JC governance structure include champions in organizations that support CoolThink@JC through a variety of activities, as well as individuals in prominent organizations related to education or technology. Members include leaders from government, industry, non-governmental organizations, nonprofit organizations, schools, and universities. This year, a new organization, ACTIT (the Association of Computational Thinking InnoCommunity Teachers), joined the governance structure. ACTIT is intended to provide ongoing support to teachers and will be led by teachers and leaders within the larger InnoCommunity. Exhibit 23 describes the members in these governing bodies, arranged by organization type and role in the CoolThink@JC governance structure.[3]

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[3] For additional information on the CoolThink@JC governance structure, see Laguarda et al. (2023).

The CoolThink@JC governance structure ensures active support and buy-in from all key system-level actors that are working to scale CTE in Hong Kong.

The CoolThink@JC governance structure represents a network of resources, champions, and supports for CTE that has been critical to CoolThink@JC's scaling. The intentional selection of partners across Hong Kong's education ecosystem has supported CoolThink@JC's reach and scalable impact. The professional collaborations supported via the initiative's various committees have contributed to the development of three key components of a robust CTE ecosystem: (1) new EDB policies to promote CTE; (2) a constellation of programs to build public awareness of the value of CTE; and (3) networks of teachers and professional development providers who have and will continue to champion CTE. We discuss each of these components in depth below.

Exhibit 23. The Trust is the backbone organization for CoolThink@JC, supporting a rich network of organizations and individuals championing the program and serving on committees to support CoolThink@JC implementation

	Steering Committee	Expert Group	Subcom. A: School Adoption & Sector Capacity-Building	Subcom. B: Public Awareness & Support	Subcom. C: Enabling Tools & Platform-Building	Consultative Group
Panel A: Organizations championing CoolThink@JC						
Representatives of…						
Convener / backbone organization						
The Hong Kong Jockey Club Charities Trust	X	X	X	X	X	X
Government agencies / affiliates						
Hong Kong Education Bureau (EDB)	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
Association of Computational Thinking InnoCommunity Teachers (ACTIT)		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 (CityU)	X	X	X	X	X	
Massachusetts Institute of Technology (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 & Support	Subcom. C: Enabling Tools & Platform-Building	Consultative Group
Panel B: Individuals championing CoolThink@JC						
Leaders from...						
Industry						
Esquel Group	X					
Microsoft Hong Kong Limited	X					
Primary schools						
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				
Professional organizations						
Hong Kong Aided Primary School Heads Association	X					

Note: *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@JC governance and are champions of CoolThink@JC. Data are from the CoolThink@JC website description of governing body members as of May 2024 (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), Chinese University of Hong Kong, Hong Kong Sheng Kung Hui (SKH), and Hong Kong Academy for Gifted Education, among others.*

Policy influence

The enriched coding education requirement is a major milestone to embedding CTE and AI concepts into Hong Kong's education curriculum.

As a result of The Trust's close working relationship with EDB to adapt and adopt CoolThink materials into the mainstream, CTE and AI concepts have become embedded into Hong Kong's curriculum. According to one interviewee, CoolThink@JC is one of the first initiatives originating outside of EDB to have achieved this level of integration.

In June 2023, EDB circulated a memorandum to announce modules required for adoption by schools to promote innovation and technology in education. The modules on coding education in upper primary grades were adapted from CoolThink@JC. Requiring implementation of CTE modules in upper primary grades supports the establishment of a culture around teaching CTE and signals its importance as a key skill for students to develop.

The modules for primary grades prioritize CTE skills and have been streamlined by a team at EdUHK with an aim to be realistic to teach in 10–14 hours. As the materials are freely available through EDB, all teachers have access to materials to teach coding for the first time. A survey conducted by EDB in August 2023 found that primary schools have allocated more time—about 15–16 hours per level—to implement the curriculum, which suggests that schools are prioritizing the learning and development of computational thinking skills.

The requirement is intended to provide primary students with consistent, foundational learning in CTE, which will lay the groundwork for building on these skills in secondary grades and beyond.

The requirement aims to instill in students basic skills in CTE, with the ultimate goal of enabling students to be producers of technology, not just consumers. In addition to streamlining the materials, the adapted materials also specify learning targets for students, giving students standardized foundational skills to build on in secondary grades.

> **[The requirement] is a very major milestone for Hong Kong, and everyone will have some sort of understanding of how computers work, what computer thinking is about.**
>
> **– System-level actor**

Hong Kong Education City (EdCity), an organization supporting effective adoption of technology-focused curriculum in the territory, is working to further expand students' access to computational thinking skills by creating self-learning modules for students in upper primary and lower secondary grades. Students may access these modules from home. Plans are also in place to create publicly available self-learning modules of CoolThink@JC.

Building public awareness

A constellation of initiatives and programmatic offerings build public awareness of the value of CTE through workshops for parents and coding competitions for students.

As noted by several interviewees, a critical component of CoolThink@JC's success is support from parents. To communicate the benefits and importance of computational thinking with parents, CoolThink@JC has engaged partners to support parent education and build public awareness. Specifically, CoolThink@JC has partnered with CityU to conduct more than 450 workshops and seminars, which have engaged more than 30,000 parents (The Hong Kong Jockey Club Charities Trust, 2024). In the 2022–23 school year, parent attendance at CityU parent workshops exceeded target attendance goals by 176%. CityU is planning to expand its supports with new programs such as Little CoolThink, in which high-performing primary-grade students become class helpers for their peers, or through greater collaboration with schools' parent-teacher organizations.

In addition, students have opportunities to apply the skills they learn from CoolThink@JC through territory-wide competitions and coding fairs. These 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 for the public.

In the future, it may be beneficial for schools to take a larger role in leading parent engagement activities around computational thinking.

A few participants argue that, for parent workshops to really have an ongoing presence and reach, it is important for engagement opportunities to be more frequent and tailored to the local community's needs. Therefore, schools may want to consider taking a larger leadership role in organizing and/or soliciting parent engagement opportunities around CTE. As one system-level actor described, if schools request supporting organizations to conduct parent workshops around CTE in their schools, "there is a pulling factor from the school side." In other words, the schools are initiating the engagements in collaboration with parent-teacher associations.

Teacher networks

Participants recognize teacher networks as a critical part of the CoolThink ecosystem that builds teacher capacity through peer-sharing.

This year, interviewees emphasized the importance of a network of teachers who are skilled in teaching CoolThink@JC, who are knowledgeable about computational thinking, and who are invested in peer-sharing as a critical component of the CoolThink ecosystem.

> **What's important in an ecosystem is that you can't not have the teachers, because we have to rely on the teachers to carry this on.**
>
> **– System-level actor**

Throughout the CoolThink ecosystem, teachers have multiple opportunities to share with and learn from their peers (although, as discussed in the earlier section on CoolThink teacher development, teacher uptake of these opportunities was relatively low). Interviewees noted the importance of teachers sharing and learning about strategies to teach CoolThink@JC, accommodating students with different learning needs through formal and informal opportunities. For example, one system-level actor described how teachers' awareness of computational thinking had increased significantly since the start of the CoolThink program:

> **Seven years ago, when you asked a teacher what is computational thinking, everyone would say, "What is that?" But now, if you go to a school and ask the teachers what is computational thinking, everyone can tell you that this is about problem-solving ... This is about doing things using your hands to learn through experiences.**
>
> **– System level actor**

Teachers are supported by a robust network of supports, including workshops, professional development, and tutorials, to build their skills in teaching CoolThink@JC and computational thinking lessons.

CoolThink@JC's network of partners has collectively devoted considerable resources to teacher professional development. CoolThink@JC has provided training for 2,000 teachers, including in-service, pre-service, and mentor teachers, offering comprehensive professional development activities on concepts related to computational thinking, coding, the internet of things, and AI, offered through organizations such as the Association of Information Technology Leaders in Education (AiTLE), EDB, EdCity, InnoCommunity, and MIT Hong Kong Innovation Node (The Hong Kong Jockey Club Charities Trust, 2024). Since 2024, these organizations have expanded their menu of trainings offered, adding in trainings on MIT App Inventor, Scratch, and small-group tutorials. In addition, the program has conducted outreach to 100% of Hong Kong's publicly funded schools and has reached 477 schools within and outside of the CoolThink network (The Hong Kong Jockey Club Charities Trust, 2024). An added support has been the sharing of CoolThink materials online, which has increased their accessibility for teachers.

> **We have the pool of 1,000 teachers already ... [and] they have the sufficient manpower to promote coding education to develop computational thinking. So, this is the most successful part of the CoolThink project because we lay down the foundation of the teacher pool.**
>
> **– System-level actor**

Notably, the new InnoCommunity teachers' association, ACTIT, aims to lead CoolThink@JC teacher development once The Trust's funding has ended. The association will be directed by four leaders with significant prior involvement in CoolThink@JC and will be supported through a network of InnoCommunity volunteer teachers. ACTIT aims to offer seminars, workshops, and opportunities for peer-sharing to promote and extend CoolThink@JC throughout the territory.

For us, the association, the main ... thing is that we don't want that fire to disappear, that spirit of it ... we need to find something to keep it burning. We don't want it to go out.

– System-level actor

Building teachers' confidence in teaching with technology remains the biggest hurdle to implementing the requirement to teach computational thinking, underscoring the importance of teacher support networks. Several organizations, including EDB, offer workshops specifically to develop teachers' skills and confidence in technology and coding.

Accomplishments, vision, and goals for the future

Because of CoolThink@JC, community members, including teachers, school leaders, parents, students, and members of related organizations, recognize the importance of CTE for students' future success.

CoolThink@JC has generated significant publicity for and activities to adopt CTE, typically through CoolThink implementation as well as tutoring and other supports for teachers and students to implement the program.

System-level actors' vision for CoolThink@JC includes scaling to secondary schools and integrating CTE across different subject areas.

Teachers probably need more co-teachers or an opportunity to work with other teachers from other disciplines to be able to deliver a cohesive experience for students, because again the App Inventor piece is a tool, but how do you use a tool particular to English class, to a math class? I think it does require a group of interdisciplinary teachers, teachers with different disciplines to come together within a school. I don't know whether we are seeing enough of that.

– System-level actor

As students progress through the school system, learning CTE throughout all subject areas, and gain more advanced skills in coding, computational thinking, and AI, they may be motivated to pursue a career in STEM.

> **Now, for everybody, all eyes are on computational thinking because it is a building block to, of course, AI. Everybody's eye is on the AI and ... CoolThink will be a feeder into [the] AI curriculum. So, the timing is just perfect.**
>
> **– System-level actor**

The long-term goal for CoolThink@JC also includes the desire to see CTE embedded seamlessly into students' everyday schooling experiences to the point where the program becomes routine.

> **If we do the job well enough, sometimes it disappears. It becomes invisible, but that's when I think, in my opinion, we've really done our job. The students just use computational thinking in everyday life.**
>
> **– System-level actor**

According to interviewees, the persistent challenges to sustaining CoolThink@JC and CTE include a need for ongoing funding to support activities, a need for more teachers and organizations to support the work, and a need to more consistently shift teachers' emphasis as they teach CoolThink@JC from coding education to computational thinking concepts. For example, one system-level actor described how teachers still focused on completing an activity rather than ensuring students had learned computational thinking concepts.

> **[Some teachers] are very focused in teaching the students the complete coding activity, and they would feel that when the student has completed the product, it's considered taught ... [the students] have completed it, but it doesn't mean that they have learned computational thinking.**
>
> **– System-level actor**

Given CoolThink@JC's reach so far and the network of supports in place, the program is well positioned to achieve long-term sustainability. As ownership of CoolThink@JC transitions from The Trust to the broader CTE ecosystem in Hong Kong, there remain important considerations to ensure success in this new sustainability phase. These include further leveraging community partnerships, expanding ongoing training for teachers, and identifying ongoing sources of financial resources to support the initiative.

Conclusions and Implications

CoolThink@JC has achieved many of the milestones set out in its initial 2020 scaling blueprint, including adoption by a critical mass of CoolThink network schools, exposure to CoolThink materials in nearly all other Hong Kong primary schools, and development of an ecosystem that will support continued training of new CoolThink teachers. Evidence of sustained CoolThink adoption in Cohort 1–2 schools suggests that most schools that joined the CoolThink network during the scaling phase will continue to teach CoolThink@JC after The Trust's support for the initiative ends.

In Cohort 3–5 schools, CoolThink@JC represents a significant departure from business-as-usual ICT instruction. Compared with traditional ICT lessons, CoolThink@JC supports creative problem-solving and student-centered pedagogies, as intended by its co-creators. CoolThink adoption also appears to shift ICT instruction in network schools away from an emphasis on digital literacy or consumption of technology and toward a focus on using technology to create, to solve problems, and to address problems important to students. Like many other innovations intended to introduce new skills, however, CoolThink@JC is proving more difficult to scale successfully in classrooms where larger numbers of students are performing below grade level.

As CoolThink@JC continues to reach more schools that have not had the advantages of network participation, success will depend on the ecosystem that The Trust has built with the intention of sustaining the initiative beyond its own leadership and funding. This new phase of sustainability throughout the territory is well positioned for success, and it will also bring with it a new set of challenges.

This study of CoolThink@JC scaling confirms the following success factors that have helped the initiative attain not only spread, but depth, sustainability, and successful transfer of ownership (Coburn, 2003). Each is accompanied by reflections, supported by this research, of issues that will be important to attend to as the lessons and pedagogy developed by CoolThink@JC continue to sustain through existing network schools and teachers while also being taken up by new schools and teachers.

- **Student experience of active learning pedagogy and high levels of engagement with CoolThink lessons.** Students enjoy CoolThink lessons, and teachers report that CoolThink@JC benefits students' creative thinking, problem-solving, and collaboration skills. Notably, Cohort 1–2 school leaders offer particularly strong endorsements of the benefits of CoolThink@JC for both teachers and students, many years after initial adoption of CoolThink. A caveat is that teachers of lower-ability classrooms consistently report greater challenges using the curriculum and more limited use of active learning strategies and opportunities for open-ended problem-solving.
- **Materials that are understandable and correctly paced for the majority of students.** Teachers report that they adapt CoolThink lessons to meet the needs of students of differing ability levels 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.

Helping teachers adapt the lessons for their classroom context, including diverse academic abilities and limited time, has always been a focus for the CoolThink team and must remain so as other organizations take on support for its continued sustainability and scale.

- **Combining a fully articulated set of curriculum materials with comprehensive teacher development to prepare teachers to teach CoolThink@JC.** Ongoing development of teacher capacity is a key success factor for sustaining change at scale. Participation in CoolThink teacher development is associated with strong confidence and efficacy among teachers, and elements of those CoolThink teacher development models have been incorporated into offerings from the growing network of providers.

  Over the long term, pilot-phase schools have relied on experienced teachers to train and support their peers to teach CoolThink@JC. Their experience suggests that strong school-based teams will continue to be a critical resource for sustaining CoolThink instruction at scale.

  One of the most important, and challenging, transitions that CoolThink@JC offers its teachers is the shift from teaching students how to code to facilitating the growth of computational thinking. As a wider set of organizations and individuals take on teacher development workshops and mentoring around CoolThink@JC, this shift must remain a primary and explicit goal.

- **Fostering school-level conditions to sustain CoolThink@JC**, including school leader support for innovation and for the place of computational thinking in the primary school curriculum, as well as strong CoolThink teacher teams. School leaders' support for innovation was associated with a variety of other success factors related to teachers, including teacher confidence, preparedness, and beliefs about the value of CTE and CoolThink's benefits for students. In addition, over the long term, pilot-phase schools have relied on experienced teachers to train and support their peers to teach CoolThink@JC. Their experience suggests that strong school-based teams are a critical resource for sustaining scale.

- **Strategic system-level ecosystem-building strategies that set the stage for successful transfer of ownership of the initiative once The Trust's support ends.** The multilevel design of CoolThink@JC's scaling strategies (classroom, school, system) is a hallmark of the initiative and may be a model for educators and education leaders in other jurisdictions who are planning to launch a curriculum-driven CTE reform effort. In particular, CoolThink@JC's broad integration within the overall CTE ecosystem in Hong Kong has set the stage for successful transfer of ownership of the initiative once The Trust's support ends.

  The Trust has assembled a noteworthy multilevel ecosystem to support sustainability and continued scale for CoolThink@JC. Participation of new schools and teachers is particularly well incentivized by Hong Kong's enriched coding education requirement that is well aligned with the CoolThink curriculum. Because leaders and teachers of primary schools in Hong Kong that were not part of any of the network cohorts have been shown to have, on average, less preexisting commitment to computational thinking than those in network schools (Laguarda et al., 2023), it will be important for those who take on ownership of CoolThink@JC to continue to think creatively about recruitment and additional incentives to promote ongoing embeddedness into school curricula.

This report has described the range of notable CoolThink accomplishments as its methods and lessons have been integrated broadly within the primary education system in Hong Kong. As an important next goal, stakeholders are looking to build on students' computational thinking abilities as they continue to grow in secondary school and beyond. CoolThink@JC is already supporting AI education at the secondary level, and MIT App Inventor lessons are being piloted in lower secondary grades. In this vision, an integrated path will both motivate sustained CoolThink practice in primary schools and substantially further the territory's goals of preparing Hong Kong's students for the growing digital economy era of the future.

In 2016, the CoolThink@JC initiative took on the very ambitious mission of equipping all Hong Kong students with the computational thinking skills that will prepare them for a fast-changing digital future. As the scaling phase of the CoolThink@JC initiative comes to a close, this agenda is well positioned to continue to succeed into the future.

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