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A White Paper

Education in the Pandemic & the Potential for Computational Thinking

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How Can We Support Educators & Students during the Pandemic?

When we spoke to Jaylen,[*] a technology director who works with elementary and middle schoolers, they were sitting alone in their office, just a few days before students were due to return to the building. "This is not normal," they said. "I can't even wrap my brain around what it's going to be like to have children in this building." Jaylen was one of the few teachers whose school was planning to bring back nearly all students for the full week in fall. "To be honest with you. I'm a little bit nervous about our ability to execute this in a way that does not freak the children out. You know, teachers are good with poker faces. But this is a big ask."

Since U.S. schools first went remote in March 2020 due to the COVID-19 pandemic, researchers have been quick to study short-term and potentially lasting impacts on education, for teachers, students, administrators, and parents.[1] As we write these words in September 2020, states around the country are pursuing a wide range of strategies, from fully remote education to bringing back all students for in-person learning, to a number of hybrid models. While the CDC[2] and the National Academies[3] have both provided "best practices" documents for school leaders, both documents encourage close collaboration with local public health officials. Ultimately, it is impossible to provide one-size-fits-all recommendations when districts must take into account variation in everything from broadband access to COVID-19 community spread.

Research can help school administrators and educators navigate the complex topics involved in education. Key research areas include tracking school district and state policies related to the pandemic;[4] COVID-19 transmission among children;[5] the unequitable obstacles faced by low-income students and families, especially Latinx and Black families;[6] and the disproportionate negative impact of distance learning on special education students.[7] Overall, researchers largely agree that student engagement and massively unequal access to online education present two of the overarching barriers when planning for the continuation of education under COVID-19.

Between June and August 2020, we spoke to 18 educators from across the U.S., all of whom said that nearly everything was in flux. Those starting the year fully online said that if COVID case numbers dropped, they might return to teaching in person later in the year. Meanwhile, those starting with hybrid or in-person options said they would likely move to fully remote if students or teachers were exposed to COVID-19. The unpredictability of the upcoming school year is a major concern for teachers as they try to arrange effective lessons for their students.

[*] All names are pseudonyms, drawn from a list of gender-unspecified names from around the world. Because educators' gender and ethnicity were outside the scope of this research, we deliberately decouple naming choices from ethnicity and gender and use singular they for all participants. Doing so helps maintain confidentiality.

Facing this much uncertainty, teachers said they shared two core priorities: supporting students' **social-emotional skills** and helping students become **independent, active learners**. They worried about student mental health, particularly about the effects of home isolation, stress, and grief. They also saw independent and active learning as a pre-requisite for successful remote education. While they knew some students had parents with the time and knowledge to help students navigate assignments, they recognized that relying on parents leads to inequity. And addressing these challenges was critical – especially since every teacher saw a return to remote schooling as inevitable at some point during the year.

One possible path towards independent and active learning may be Computational Thinking, or CT for short. CT is a problem-solving methodology and a pedagogy which focuses on breaking down problems into smaller steps and coming up with reusable solutions.[8] While the name may sound like math and computer science, **computational thinking is "more about thinking than computing,"** as a number of researchers wrote in a recent editorial.[9] It's a way of structuring academic inquiry that can be applied across disciplines.

As one elementary-school classroom teacher, Zane, put it, CT is *"the idea of looking at something that feels utterly overwhelming – like life right now – and figuring out how to break that into smaller pieces so that it becomes manageable."* In this white paper, we outline the challenges facing U.S. education right now, and how and why CT is a valuable addition to teachers' toolbox in school systems across the country.

Throughout this white paper, we use *we* to refer to the five co-authors. We are all social scientists, members of a team that has been conducting research to understand teachers' and students' ability and confidence to think computationally. Since 2016, we've been working closely with a team that develops interventions and tools for classroom use. Several of us have worked as teachers, and we have all worked closely with teachers and informal educators.

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The Current Context: U.S. Education during COVID-19

Between June and August 2020, we interviewed 18 educators.[10] These individuals represent a range of administrative and classroom roles, geographic areas, and types of schools. Together, their insights illustrate the uncertain landscape of the U.S. education system at the outset of the COVID-19 pandemic. In this chapter, we describe educators' major considerations for student learning in this new context, with stories from teachers in their own words.

Teachers saw **spring 2020** as a period of "emergency remote learning" and generally said that they had done the best they could under impossible circumstances. By the **fall**, they had largely come to accept COVID-19 as a "new reality" rather than a passing phase, and were focused on making up for and preventing learning losses. While all teachers had gotten some experience teaching online in the spring, few teachers said they were confident in their plans for the fall. Some found it disheartening to spend so much time planning with no sense of what would or wouldn't work in their new teaching setting. Zane, for one, foresaw having to make a lot of quick adjustments to meet the needs of their students, and daydreamed about the ability to "*make plans based on feeling what it's actually like to be in a space with everybody far apart because my imagination is limited.*" Many teachers also said they assumed they would have to go fully remote again at some point this coming year, and they were frustrated by fall plans that felt unrealistic or did not take into account what they had learned from the spring. As Huan, an elementary school technology specialist said, *"We are trying to do a little bit of everything rather than put all of our energy into a really great remote model."*

Education Now Relies on Computers

In the spring, school buildings shut down, which meant that schooling took place through a combination of paper packets and digital technologies. Instead of a full day with students, the fifteen interviewees who engaged directly with students between mid-March and June did so for only a limited time each day in the spring. Teachers generally agreed that it was best to work in a "flipped" model, combining self-guided activities and videos – ideally administered through a learning management platform like Google Classroom – with short live meetings to go over those activities and answer questions. However, many of them spent the early spring ensuring all students had internet and device access and were only able to meet with students after one to two months of frantic preparation time. At the end of that hurried period of laptop and hotspot distribution, many teachers were still concerned, but they thought that access issues had been addressed as fully as possible by the fall. Going into the fall, most teachers were starting the year either fully remote or teaching in a hybrid model, where students were split into groups that met in-person for half the week and

online the other half. That meant most students would continue to access at least part of their education from their homes, most likely through the computer.

This heavy reliance on computers created additional stress for teachers with strong technical skills, a number of whom were moved into coaching or tech support roles. Cemre, a long-time computer science teacher became a technology coach over the summer, responsible for supporting 1,500 students, nearly 100 teachers, and about 25 paraprofessionals in their school district. *"My phone turns off at 10 o'clock at night,"* they said*, "and I tell teachers at that point in time they have to leave a message."* We spoke to them during the second week of school in the fall, at which point they said they were *"24-hour support for teachers … to ensure that kids are being taught in some shape, as opposed to sitting there watching a video."* In a similar vein, Jyoti – who was both a technology coordinator for the school and a technology teacher – said that their coordinator role had ramped up considerably since March, without a corresponding decrease in their teaching load*: "It was almost like I was being abused. I was being asked to do so much… and then being almost told I didn't do enough."*

Uncertainty Is the Only "New Normal"

Almost every teacher noted that they foresee their plans changing. Districts generally planned to reassess at the end of the first marking period or semester. Researchers have also advocated for this strategy.[11] However, those teachers who planned to spend at least part of the school year in-person said that another relatively sudden closure was not off the table. For instance, Ivo, a science teacher, remarked, *"We keep being reminded that it can change any day."* Jaylen – whose school planned to give both remote and in-person students the ability to change their minds after six weeks – put it most bluntly: *"Most of our teachers here pretty much believe that we're not going to last six weeks, that we'll be online anyway. …There is a general belief that this is a lot of effort for us to be open for two to three weeks or a month or something, and then we'll all be online anyway."* And even teachers who were optimistic about in-person learning assumed that everything would change once they had students in the classroom. Teachers considered keeping students appropriately distanced and sanitized a substantial challenge, and they generally assumed their best-laid plans might require real-time revision.

Helping Students Become Active, Independent Learners

In the spring, teachers' main concern was simply getting students online – and keeping them engaged with one another and the school community. As fall approached, those challenges remained top of mind, but teachers were also able to turn their attention to learning once more. The limited amount of interaction with students, whether limited by only seeing students in-person twice a week, or seeing students for limited time online each day, has pushed teachers to rethink the most efficient ways to prepare students to learn. And once students are in the midst of learning and class activities, teachers said one of the hardest things about remote instruction, especially in younger grades, is getting sufficient insight into students' learning – and helping them shift gears if necessary. It's much harder to know how everyone is doing when an educator can't simply walk around the room. Furthermore, it's hard to provide ongoing and interactive feedback either online or in the socially-distanced classroom. Under pre-pandemic circumstances, teachers used both verbal and

nonverbal communication, which are critical to building relationships and trust. For instance, they were able to convey meaning with eye contact, a quick smile, gesture, or a one-word private reminder. But none of those practices have clear remote equivalents.

Teachers now recognize that they have to help students become maximally independent – and the younger the student, the harder that can be. Ivo, who teaches middle school science, had compassion for students struggling to stay on task at home: *"If you have a small class, and you can do interactive things, at a certain age group I think [fully online learning] works. College students can go out and do breakout groups, but when you're little, you have a lot of other things competing."*

Everything Is Ethically Fraught

Teachers expressed equity concerns throughout our conversations, beginning in the spring and continuing through our conversations in the fall. They were troubled by everything from their schools' inability to provide legally required accommodations to differences in internet access to worries about language access, to the effects of having parents working in "essential" jobs. We also heard a number of teachers' worries about the inequities of COVID-19's economic and health impacts, especially when it comes to students of a variety of socioeconomic levels, races, and ethnicities. These impacts, according to teachers, will likely threaten many aspects of students' wellbeing, including their learning.[12]

Teachers didn't always use the words "equity" or "ethics." But when we reviewed their comments together, we found these were underlying themes. Rather than addressing equity as a single concern, we have chosen to remain true to the spirit of our conversations by focusing on five of the ethical trade-offs teachers found themselves navigating. These are not the only trade-offs teachers felt conflicted about. They mentioned additional ethical concerns and likely did not discuss others. We selected these five because educators and school districts could potentially address these issues.

Trade-off 1: Visibility versus Privacy

All teachers said that remote learning makes it harder to maintain a sense of where each student is in the learning process and to give individual feedback. They thought going back in-person, even part-time, might help them gain a better sense of student progress – but that it would be impossible to give feedback privately in the socially distanced classroom. They simply would not be able to get close enough to see a student's work or speak to them without others hearing. For teachers who were fully remote, the trade-offs were even more difficult. Most high-stakes testing was canceled in the spring, but that was a short-term solution. Educators were deeply concerned about the role and value of testing in the fall and beyond.

Tal is an elementary-school classroom teacher who was initially excited to return to school in a hybrid model. When they found out students were not required to wear masks – and that they would have a full classroom four days each week – they applied to teach online instead. Tal is now starting the year with nearly 35 third graders. However, they expect that their students *"are basically second graders, because we shut down in March and then … everybody was kind of doing their own thing as far as what they decided to do with their kids. So I need to figure out where they are, and meet them where they are, and provide supports for them to bring*

them up to par." We spoke to Tal in the morning, a week and a half before school started; that afternoon, they planned to call the family of each and every student to start building individual relationships.

Tal thought it would be easier to monitor engagement and progress with student cameras on, but they had concerns about student privacy. *"There's this big agreement-disagreement with whether to have kids have their cameras on because we don't know what's going on in their background. Maybe they have a messy house, or they're embarrassed, or their hair isn't the way it is. So there needs to be, if their camera's off, there needs to be a way for us to notice that they aren't there, that we've lost them."* For Tal, seeing students' faces via camera was not worth making them uncomfortable. Instead, they wanted more interactive tasks that would flag for teachers when students started to struggle. *"There must be some way where we can see that they've been on something for quite a while and gauge that 'Oooh, that's probably a little tricky for them. I need to go in and help them.'"*

Trade-off 2: Structure versus Comfort

Teachers also find themselves torn between providing structure and making students feel at ease. They recognize that the pandemic has been difficult for students, including many who may need some grace to figure out how they can learn best. At the same time, educators see structure as a way to create effective conditions for learning.

Eder, who teaches middle school science, was always told *"Everyone knows you do not smile until Christmas break"* because *"you don't want students becoming too comfortable."* We spoke to them on the very first day of school, just after they had told all their students that *"mics need to be off, when you come in, [and] you can have the camera on so I can learn faces and names unless I give you instructions otherwise. So I have students who are like, 'Well, I have a question or something' and they unmute themselves, so I brought them back: 'Alright, so what is our procedure?' For being able to ask a question, you raise your virtual hand, you wait for me to call on you and tell you to unmute your mic so that it lessens distractions and background noise."* If anything, they said that classroom management was even more important online than offline – especially in the first few weeks.

Eder planned to start out the year by helping students navigate the learning management platform, then reviewing lab safety and nature of science. That felt like an opportunity to start with structure right away: *"I want to give them discipline, but I'm not there to overwhelm them because … that's not going to help them. I don't believe in powering through something because we have to cover material because that doesn't prove effective, and you can see it in their engagement, you can see it in their assessment."* Even though structure was a priority, Eder still gave students more opportunities to socialize on the first day than in prior years.

Unlike some other teachers, Eder also found it easier to identify when students were tired on video chat than in the classroom*: "I can see when they're being drained. I can visually see that now. You can see it in the classroom, but it's like, there's so many things … happening versus like it's right in front of your face."* And given this ability to see when students are struggling, Eder finds themself asking, *"Do I want to power through and be that very disciplined, very structured person, and then they, like, literally hate coming to class, but they know that there's work going to be done, or can I do a mash up of both?"*

Trade-off 3: Parental Support versus Student Autonomy

Teachers were quick to identify both positives and negatives of parental involvement. On the one hand, many teachers were excited about parents' increased attention towards the school curriculum and their newfound appreciation for teachers' work. A handful of teachers also noted that schooling at home was an opportunity for parents to better identify what their child struggles with and how they can better be supported. On the other hand, teachers recognized parental involvement as a major challenge to equity. Some students' parents had time, computer know-how, and familiarity with the subject matter – and others did not. And with no way to monitor parents' involvement, a few teachers worried about who actually does the majority of work the students turn in. Communication with parents about updates and student needs was challenging for teachers in the spring. By fall, many schools had attempted to streamline communications on a schoolwide level so each teacher did not have to independently contact parents. Teachers in those schools felt better prepared to keep parents involved moving forward.

Linh, who teaches middle-school English, felt lucky to have students who were old enough to be somewhat tech-savvy. Linh also saw opportunities for remote learning to further build student independence, even as they recognized the need for parental support. *"Because of the situation we're living in right now, they're learning to become independent. And I think this happens even in elementary, because even if they do have a parent that's sitting next to them, or an older sibling, or whoever is helping them, they're learning that they can take charge of their learning."* They still recognized that involving parents made their own work considerably more manageable.

At the same time, Linh was also frank about equity concerns resulting from parents' different abilities to support their children. *"Some parents are back at work. So they are not with their child, they're not supervising to see if the child is working, at least even engaging with us. And some parents are at home, but they're working. So they still may not be able to supervise their children. If they're comfortable with technology, whether it's because of their work, or whether their situation is that they don't have a job right now, and they're not able to work with the children."* If parents attended the virtual open house and other trainings offered by the school, that was ideal for Linh, who did not have time to reach out proactively to parents who did not attend.

Linh also felt uncomfortable directly reaching out to parents because doing so might inadvertently violate a family's privacy. They said, *"Many of the numbers we do have in the system are their office numbers. And we don't even know if they're there right now, and it is a very delicate topic. So we wouldn't want to call if that person isn't here, the company doesn't exist anymore..."*

Trade-off 4: Passive Screen Time versus Active Learning

Because many school districts were planning more live online instruction in the fall, teachers raised concerns about "Zoom fatigue," from too much time looking at the screen. They pointed to research and articles they had read that show excessive screen time can affect children's sleep schedules, and can be dull because of the lack of personal and social interaction. They also lamented the loss of two major in-person pedagogical tools they had

relied on in the past: **hands-on activities** and **group projects**. Even if learning happens in person and these two learning activities are technically possible, educators worried about hygiene and practicality issues with yelling across the room and sharing tactile materials. Basic safety protocols for teaching in-person – such as maintaining safe distances and sanitizing surfaces – are requiring teachers to rethink other teaching models they relied on before the pandemic as well.

Teachers saw opportunities among the many obstacles. Some said it was easier to ask students to relate curriculum topics to the real world when they were learning from home. Marijn, a fifth-grade science teacher, tried to offer many such assignments: "*You know, look around your neighborhood. Go on a scavenger hunt. What things do you notice – is there trash around? Make a poster that you hang up in your neighborhood or make a video or something like that, that was kind of different than what we could show them in school*." At the same time, teachers noted that these "real-world" assignments require students to work independently and outside the home, which is not safe or feasible for all students.

Gita is a science department chair and a middle-school science teacher. When school went online in the spring, their school quickly pivoted to sending students two self-paced lessons per week, with an optional synchronous meeting with each teacher. At the time, this was a compromise so that students could get their work done at times when parents were available to help; the district thought it was better to have students working on their own schedule rather than having to do things at a particular time of day. Even in the spring, Gita was concerned that the easiest way to teach online was to deliver a long monologue, without having cues or interactions that could signal students' comprehension. They reflected, *"It could be really easy for me to just talk for half an hour and say, 'You understand this? You understand this? You understand this?'"* In the fall, the amount of screen time was a particular concern because their district was providing considerably more live online instruction. They said, *"As we move to more synchronous learning, it seems like students and teachers are going to be required to spend larger amounts of time in front of screens at specific times, so [we need to be] making sure that they have the brain breaks and the mindfulness breaks that they need to be successful and not just be like computer zombies that have been staring at a screen for six hours."*

But Gita had big plans for creating interactivity and community to counterbalance potential negative effects of extended screen time and reduce the amount of time students spend on passive activities, like watching videos. They were *"really planning ahead to provide checkpoints where I could say, 'now we're going to go into small group and breakout rooms, and you're going to talk this over with three or four people.'"* They also planned to provide a Google Drive where students could create shared photo albums to discuss their lives at home. Gita's school also recognizes that not all students are able to work completely independently with online learning, and is putting safeguards in place. Their school is *"making sure that [students], especially students who weren't engaged last year, go into this grade feeling like they have a teacher that they can talk to and touch base with in a reliable way, either in person socially distanced or virtually through Google Meets and things like that."*

Trade-off 5: One-on-one Attention versus Physical Safety

As students transitioned to online learning in the spring, educators observed that the varying levels of support and one-on-one attention students rely on in school were not

always available at home. Teachers spoke about students who struggle with organization and attention, and rely heavily on support from teachers or teaching assistants. They worried that these students are incredibly vulnerable to the current changes in education. Thando, a technology coordinator, wondered how districts could remotely meet the needs of students who used to receive full-time support from a paraprofessional. Teachers who worked in immersion classrooms said they make an extra effort to reach out to parents of students with Individualized Education Programs (IEPs), but not all caretakers can be expected to provide one-on-one support to their children all day, like the support some students receive in school. For example, Tal, the elementary classroom teacher, noted that of three students with IEPs in the spring, only one attended regularly – and that student was the only one of the three whose parent had the flexibility to sit next to them all day. There is also concern for students whose learning style requires more repetition of information and instructions that might not be possible in online lessons that address the class as a whole. Some educators also acknowledged some advantages of online learning. Namely, students who struggle with distractions in the classroom or work at a different pace than other students can benefit from the independence remote learning offers.

In their fifth-grade classroom, Marijn is used to differentiating for students with *"educational disabilities, attention disabilities, and behavioral concerns."* But they dream of having a paraprofessional – often called a "para" for short – an extra adult to help meet everyone's needs. Marijn reflected, *"If I could have anything in the world, I would wish every teacher could have their own para for the whole day in their classroom, just helping them out with small groups and just pretty much another support system in there for students. If someone needs a break, or just sitting with one student who might have attentional or emotional or social needs … I think it would just make a classroom ten times better."*

In the fall, Marijn was particularly worried about students who needed extra care to begin with. With hybrid schooling, they asked, "*What exactly will be a para's role? How will they be able to help out? One thing that I've assumed would happen and has been thrown around is that maybe paras would be paired up with those students who don't have an IEP, but certainly do usually get a little extra, you know, attention by a small group or by a para. So I would hope that a para would maybe be paired up with one or two students, and they meet virtually, you know, a few times a week or whatever need be. To help them out, check in – 'What's going on with your work? Did you read through this?'"*

Further Trade-offs

The educators we spoke to mentioned a wide range of other issues. These problems included concerns about their own physical and mental health and that of their families, class sizes that are too big, teacher compensation, and a nationwide reckoning about racial injustice, among others. In our conversations, teachers did not tend to focus on these structural challenges and instead spent more time discussing the ethical issues that they did have some control over. In that same spirit, we have based this white paper on the topics that we felt teachers and school districts could address.

Computational Thinking in Teachers' Toolbox

The challenges described in the previous chapter indicate that the pandemic can harm the learning and overall wellbeing of a wide range of students in the U.S. There is no education panacea that will remedy the problems of every student in all school districts. But there are pedagogical techniques that can alleviate some concerns and inequities across grade levels, subjects, and geographies. Teaching students *how* to think can be a powerful tool.

One way of doing this may be with computational thinking – CT for short. CT is a problem-solving methodology that can support independent, active learning. CT asks students to break down big problems into manageable parts (Problem Decomposition), look for **patterns**, and use those patterns to find generalizable solutions, or algorithms. Once the generalizable solutions are established, the final step is figuring out how to apply that solution elsewhere (Abstraction). Ultimately, CT is a way for students to figure out what they already know and what they still need to find out. Students can use CT deliberately to design **algorithms** – routines or procedures that can be used repeatedly – so that they don't have to reinvent the wheel with each new problem. And in fact, everyone relies on personal algorithms to structure their lives: Just think of what you do to get ready for bed at night.

While many teachers saw CT as a much-needed opportunity for transforming education, others continue to think of CT as a specific set of activities, often related to robotics, coding, and other kinds of hands-on materials. This second group of teachers was frustrated by practical hurdles, as described previously. Educators who are more familiar with CT saw a great deal of potential for using this methodology during the pandemic, and beyond.

The educators we interviewed explained CT as a multifaceted, adaptable tool that can be used for online, hybrid, and in-person learning. If anything, some of the technology teachers saw remote learning as an opportunity to expand CT and rethink education more broadly. Jyoti reflected, *"I feel like [CT] can play a very powerful role if we let it... Now that we're all remote, maybe we should stop teaching the way we've been teaching since the 1800s. Right? We're still using textbooks.... [In remote learning] we're teaching them how to research and we're teaching them how they can display their work. Which is all computational thinking."*

Many educators are already re-envisioning what education could look like. Cemre – the computer science teacher who became a technology coach – saw their colleagues' new interest in CT as the one bright spot. They said, *"Because they are in an online environment, they're looking at ... adding computational thinking into their lessons. ... I love this because I'm being asked, 'How do I put this in?' And I realize what they're asking me, without asking directly, is, 'Computationally ... how do I get this information to this child?'"*

Educators who are familiar with CT have many ideas for using CT in remote learning. Huan, a tech specialist in an elementary school, recommended fort building as a CT activity that can be done remotely with students at just about any grade level, using materials that all students are likely to have at home. Students first have to make a plan for how they'll make that fort and how it will work. Huan asks questions like, *"And why will this hold up the blanket*

like this? And what are you going to need for this? And how can we make our fort?" They saw this as a fun parent child-activity that could also teach the problem-solving skills students would need to learn independently – and students could share pictures with one another and with their teachers. As Huan observed, this activity is maximally flexible: *"You can pretty much make a fort out of anything. No matter where you are, you have a blanket."* Another low-resource activity that Huan had their students do at home was make a "barge" in a bowl of water and see how many pennies or pencils they could balance on top.

What Can CT Do?

CT can help address some ethical trade-offs that teachers are concerned about. Below, we describe how CT responds specifically to each of the five trade-offs described above.

By asking all students to follow the same problem-solving steps, CT can help provide **visibility** into their thinking process. It gives teachers and students a shared language to pinpoint where students are struggling. For Marijn, *"a big part of [CT] is letting students explain their thinking. How did you get to that answer? And was your system the same way of solving it as someone else's?"* Jyoti was also hopeful that CT could help teachers make connections across subject areas *"so that the content that they are teaching is still the same, but they're using the language [of CT] more … by using the language, you are actually helping them to embed those concepts within their teaching, which helps embed the kids."*

A number of teachers we spoke to in the fall planned to front-load CT as a way of providing **structure** to support students for what they saw as an inevitable transition back to remote schooling. They often used the terms *routines* or *algorithms* to describe this level of structure. Zane, an elementary-school classroom teacher who was starting the schoolyear with a hybrid model, planned to kick off class activities with *"computational thinking skills applied to logistics."* And Dayo, who leads a school that serves only special education students, was spending the summer reaching out to parents about creating healthy morning routines to support remote learning. They said the first few weeks of school would be spent on developing classroom routines to build on the at-home routines.

CT pedagogy can be used across all disciplines to help promote students' **autonomy**, independent of parents' ability to support learning. Linh, who teaches middle school English, had never used CT but was excited to learn more and put it into action. They said they had spent years of their career trying to find a way to help students see that writing follows a consistent process. *"One plus one makes two and the same thing works for writing. If you have a formula for writing that you can use over and over again, it doesn't matter if you're in seventh grade. It doesn't matter if you're in college. It will still work for you."* Zane had similar thoughts. In fact, Zane saw a role for computational thinking in routines and rituals across the entire school building: everything from determining bathroom occupancy during COVID-19 to working together to figure out how to play a game while maintaining a 6-foot distance between students.

Active learning goes hand in hand with autonomy, and several teachers connected CT directly to project-based learning, where students explore real-world challenges on their own. Shelby, who teaches technology at both the elementary- and middle-school levels, is lucky enough to work in a district that has adopted CT broadly across grades. Like some

other educators quoted above, Shelby wanted to make connections across the curriculum. They said, *"For every single class you take, you use computational thinking. Even if you're in gym class, and you're learning how to throw a ball, you have to learn how to do that. And that brings in patterns, because you have to have the right pattern to throw the ball."* In fact, Shelby went further than any other teacher in describing how vital CT is for students right now: *"Given this pandemic, I think that computational thinking is a skill set all these kids need to survive."*

CT can enable teachers to create a system where students can easily signal both when and how they need **one-on-one attention**. In our five years of research[13] on CT, we've often heard teachers say that giving students a process to follow when tasks seem too big – and language to talk about that process – helps them work more independently, without getting overwhelmed. Learning a step-by-step process can work especially well for students who have trouble staying organized or identifying the next step, including many students who have received IEPs. That means they may need less individual attention in the first place. When students do hit a roadblock in their process, having shared language about these problems equips them to quickly communicate with a teacher. This skill can help in remote learning settings when a teacher can't always see what the student is working on.

What Next?

As experimentation with education systems in the U.S. continues, new opportunities and challenges will likely emerge. Come what may, teachers, administrators, policymakers, and funders will continue to have a stake in supporting students' ability to not only learn, but also thrive. The problems that have already shown up make it clear that one product or program will not be able to help every student. Yet, a systematic, problem-solving methodology like CT can address a variety of needs in this uncertain landscape. Specifically, CT can help both students and teachers share a system and language for learning in remote education models.

Before teachers can try pedagogical tools like CT, they must have a firm foundation to stand on. During this time of rapid change in education, **teachers need support**. Period. The transition to remote learning and hybrid models requires ongoing professional development in online instruction. In parallel, educators, especially those overseeing technology, will benefit from additional training and resources for technology platforms. Together, these investments will enable teachers to be more confident and effective in guiding students. Another worthwhile support strategy will be equipping teachers to collaborate. Collaboration can seed creativity and enthusiasm, as well as reduce a sense of social and professional isolation.[14] It can empower teachers like Jyoti and Cemre, who want to share knowledge and information about pedagogies likely to work well in the current environment of education. Formalizing collaboration and peer-to-peer learning can further recognize this important work.

If readers are interested in learning more about CT, researchers and educators recommend these resources:

- **Barefoot Computing** – an organization that empowers teachers to use CT in the classroom (based in the United Kingdom, but accessible for other audiences as well). Barefoot provides CT resources applicable across the curriculum, on- and off-line. See more at: *https://www.barefootcomputing.org*
- **Code.org** – a platform that expands access to computer science in schools and increase participation by young women and students from other underrepresented groups. See more at: *https://code.org*
- **INFACT** – This project team is infusing CT in elementary and middle school STEM learning. They will be creating CT curriculum, assessments, and professional development. These tools will pay particular attention to addressing the needs of a wide range of learners, including neurodiverse students. See more at: *https://www.terc.edu/projects/infact/*

What We Did

Knology researchers conducted two series of interviews in 2020. In the first interview period, we spoke to 12 educators between June 2 and July 9. Our second interview period, from August 11 to 31, included eight of the individuals we spoke to in June, as well six additional educators at that time. In total, we spoke to 18 educators.

Our original goal was to understand educators' experiences and concerns at these two points in time: spring 2020, while they were reacting to unanticipated changes, and early fall 2020, to reflect on those changes and on the future. But speaking of unanticipated changes, the course of the pandemic itself altered our plans considerably. When we first conceived of this research in early April 2020, we had every reason to believe that schools would be able to reopen safely in the fall. By the end of July 2020, it was clear that many districts would reopen remotely and that even those districts that opened in person might have to return to remote learning on and off throughout the 2020-2021 school year. The interview protocol was semi-structured and conversational to accommodate a wide range of different circumstances; in practice, no two conversations took the same exact turns.

The 18 educators we talked to included one administrator, one English teacher, two coaches, three elementary classroom teachers, four science teachers, and seven people who offered some form of technology education, whether teaching computer science or coordinating instructional technology. They came from around the country: California, Connecticut, Florida, Maryland, Massachusetts, Michigan, Virginia, Washington DC, and Wisconsin. Most of them worked in public schools, but three worked in private schools and one worked in a charter school. All teachers we interviewed were interested in, generally familiar with, or experienced in using CT. We recruited teachers for this study through research partner's networks.

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About Us

The five co-authors of this white paper are researchers at Knology. Knology is a non-profit research organization that pursues practical social science for a better world. The organization is a transdisciplinary collective of over 30 social scientists, writers, and educators based in New York City. See more at Knology.org.

Endnotes

1. See Reich, J., Buttimer, C. J., Coleman, D., Colwell, R., Faruqi, F., & Larke, L. R. (2020, July). What's Lost, What's Left, What's Next: Lessons Learned from The Lived Experiences of Teachers During the Pandemic. Available at: *https://edarxiv.org/8exp9*.
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8. For more information, see Shute, V.J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research*, 22: 142-158; CS for All. (2020, June 16). Assessing Students' Computational Thinking Application in Core Subject Areas. Computer Science for All. Available at: https://medium.com/@CSforALL/assessing-students-computational-thinking-application-in-core-subject-areas-b6799b117493.
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10. We spoke to eight of these teachers twice, and the other ten only once. See the What We Did section for details.
11. See Reich, Buttimer, Coleman et al, 2020.
12. Other researchers noted these concerns too. See Reich, Buttimer, Coleman, et al., 2020, pp. 12-14.
13. See, e.g., https://knology.org/article/cultivating-computational-thinking-in-grade-school-learners/
14. We wrote about the need for support in more detail here: *https://knology.org/article/teaching-in-the-age-of-covid-19-computational-thinking-and-support-for-educators/*

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