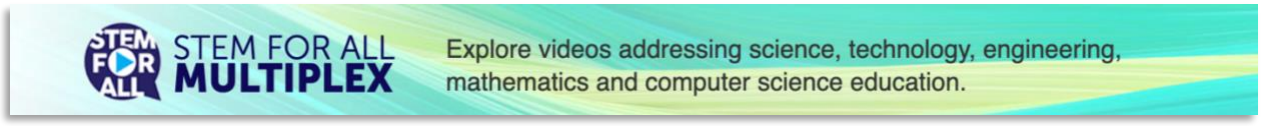

Integrating CS (computer science) and CT (Computational Thinking) in the Pre K-8 Grades
Multiplex monthly theme, June 2020
Synthesis

This month's Theme, "Integrating CS (computer science) and CT (Computational Thinking) in the Pre K-8 Grades" takes place in the context of three important developments in education and society: the need to make CS and CT broadly accessible in the early grades, the need to integrate the two, and the importance of CS/CT for equity.

CS for all. The CS for all movement has gained momentum in recent years. On the one hand, the "CS for all" campaign has taken seriously the challenge of making CS and CT part of the "educational core," along with science, mathematics, literacy, etc, The accessibility of CS/CT has been recognized as an avenue for broadening participation in STEM more generally.

CS is joined by CT. The message has moved beyond the teaching of CS and coding (e.g. with the "hour of code" activities, the explosion of robotics and maker activities involving digital devices, and the widespread use of environments such as Scratch). While these remain important, educators and learning scientists also developed an understanding of "computational thinking" as a way of understanding many aspects of learning and problem-solving, which could also serve as a preparation for, or gateway to CS.

CS/CT and equity. There is also a growing recognition that technology is not value-free—naturally, as it is a social product. Technology (most recently through AI algorithms) is not only helping us to make decisions, but is actually being empowered to make decisions for us. What's built into these systems? The "ethical computing" or "ethical algorithm" movement argues therefore that our algorithms and other systems should be scrutinized to remove bias — or more positively, to promote social fairness, asking "How do we scale CS/CT in a way that does not perpetuate social norms of inequity?"

Why CS/CT in Pre-K-8 grades?

In these grades, CS/CT activities are foundational for further knowledge. CS/CT are integral parts of the world these children inhabit — you could say they are second-generation digital natives. At this age, the focus on habits of mind is best addressed in unplugged as well as "plugged" activities. Now is the time also to help students learn "digital citizenship," and learn about safety and responsibility.

Taking an integrated approach, in which CS/CT are a natural element in learning and exploration helps the children engage in fresh ways with curricular content. In this way, girls and others often under-represented in the CS/CT world can find its value as a part other activities (drama, math, science, music, reading and writing) that may be of particular interest to an individual child. It can give them an opportunity for making choices about their learning and their making, and for learning persistence and the "debugging" mindset of thoughtful improvement on one's knowledge and work. At the same time, CS/CT offer children different ways for showing their learning. Increasingly as well, CS/CT curricula (see Resources) address social-emotional learning and the culture of kindness. Finally, CS can offer tools and resources for differentiation of instruction, supporting personalized and equitable learning.

What does student learning with CS/CT look like?

The expert panel and webinar attenders brought forward a wealth of experience from the field in this connection. Many spoke of their teaching or support of CS/CT in the elementary grades being powered by the emerging CS/CT curriculum frameworks. There are new developments as well — the development of standards and resources for artificial intelligence (AI) for K-12 is very exciting — and how we integrate that into the K-12 curriculum is still an area of active debate and experimentation.

Another new development which relates to equitable engagement is that many schools are moving past CS as an elective subject, rather treating it as part of "general education" offered to all. This helps ensure that all children in the schools can see CS/CT as a matter of course, so to speak — something that shared by all their peers. This likely will have longer-term consequences. As one panelist said, "The earlier you can get a kid to see themselves as a computer scientist, the more likely is that they'll continue with CS as they get older," when in middle and high school CS may be offered as an elective course.

Finally, CS/CT educators in elementary schools, like their colleagues in literacy and in other STEM fields, recognize that equity and engagement for young children often begins with the families. This has led to CS or STEM nights, designed to bring parents to the school to share activities with their children. This both supports the children, and offers new resources and knowledge to parents and communities.

Teacher preparation and support

Pre-K-8 CS teachers, like many STEM teachers in elementary school often have little college experience. in CS. At the present time, the preparation at the pre-service level, as well as in-service learning for teachers, varies widely among districts and schools. Again, this an area of experimentation and change. One of the experts on our panel is able to devote 4 weeks to CT/CS, Scratch and block-based coding, in her educational technology course for pre-service teachers. The hope is that if these teachers-in-preparation understand the basic concepts, and have some familiarity with appropriate tools , they'll go on to think about how it can fit in their own practice as it develops. It appears that relatively few pre-service programs offer so structured and intensive a course yet, but maybe half of pre-service programs are doing some CS/CT even if just "hour of code." Again, at the level of certifications, states variety widely. A few states have certifications in CS/CT (in some form), while others (Indiana was mentioned) require all K-8 grades to teach CT CS, and so set expectations for the teachers as well as the students.

In service learning in CS/CT as in other fields takes many forms. External providers (non-profit as well as commercial) play an important role of external providers. Since the Obama administration placed a high priority on getting as many teachers trained as possible, there has been a lot of momentum to train as many" boots on the ground" as possible. Many of these programs offer 3 critical components needed to support teachers' changing their practice: - experiential and formal training, usable curriculum materials, and community offered all in one place. This represents a revolutionary way to integrate CS into the schools. Many of these providers help them emphasize the integration of marriage of CS with great teaching — helping teachers enrich their already-developed pedagogy with this new array of ideas and tools. Discussions on equity are also central to many of these in-service programs. Beyond these learning resources, there are a growing number of blogs and forums by and for teachers. As

with any innovation, this is an area which requires much experimentation, trial-and-error, and collegial discussion about what works, when, and for whom. So, even though there is a long way to go in making them available to all teachers, there is an increasing wealth of resources and strategies for in-service learning in CS/CT.

Equity What does it look like? How do we do it?

Though for a long time, concern about the "digital divide" directed policy makers' attention to increasing access to digital tools and infrastructure, the field is increasingly aware that access ≠ equity. A more mature approach, made possible by the near-ubiquity of digital devices in everyone's life, focuses on making the concepts and methods of CS a part of everyone's education and personal toolkit. The CT movement has contributed new insights and strategies here, recognizing that while not everyone will want to become a computer scientist, a recognition of the computational elements present in everyday life and in practices of all kinds can build a sense of empowerment and opportunity: this is identity-work, as well as much as skills-building A key approach has been mentioned already: integration across the curriculum.

There are many areas in elementary grades that allow the seamless integration of CS/CT using plugged or unplugged activities. Here are a few ideas:

- Identifying and discussing problem solving strategies.
- Sorting activities
- Revising work
- Using digital tools to connect and collaborate. This can be accomplished within your own classroom, but collaboration can also occur within the school, district, state-wide, etc.
- Creating research based products

Recommendations for teacher leaders

- The integration of CS/CT into the elementary grades is an area of experimentation in practice for teachers. Teacher leadership can take the form of sharing one's own trials and errors, both in finding resources for PD and continuing education as well as the classroom, and in translating the learning into practice.
- Teacher Leaders can help ensure that equity and ethics are present from the beginning in PD and in the classroom materials, both by advocacy themselves, and in supporting teachers within their school or district who are making successful innovations in this area.
- Very often, collaboration among teachers with different skill sets is the most effective way for a school to improve as a whole. Teacher leaders often play the role of encouraging the culture of learning among their colleagues — first by example, and second by welcoming leadership from others — and ensuring that all voices are heard and engaged seriously.

Recommendations for researchers

- The CS/CT innovation is still very new. The values and materials, standards, learning progressions, etc. are still under-studied. From the point of view of student learning, it is important to examine critically many of the developing "conventional wisdom" in this area — such as the many ideas reported above drawn from our panelists and participants

about the effectiveness of integration across the curriculum for learning CS/CT; for its impact on student engagement in other subjects, and their increased participation in CS, or STEM, later in school or in careers — and many others.

- Research on teacher learning and practice is also very much needed, if we are to identify fruitful approaches to teacher learning, effects on school culture, and the reinterpretation of subject matter when CS/CT are indeed integrated, beyond the pioneering stage of implementation

Recommendations for policy-makers and administrators

- It is clear from the panel and participants' evidence that collaboration among teachers is an important avenue for the integration of CS/CT into elementary instruction. This requires careful attention to the development and support of a culture of teacher collaboration and learning. As with any innovation, "culture" involves such concrete factors as teachers' schedules, and permission to collaborate and learn.
- Teachers' learning and innovation should be supported by good-quality professional development, together with access to teacher learning resources as well as classroom materials. The research on professional development shows that PD for substantive change in practice should be extended over time, be grounded in the curricular content, engage teachers as active learners, and be accompanied by the culture of professional learning within the school.

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