CITE Guest Speaker Series

Everyday Choreographies as Pathways for Building Computational Literacies

Noticing, Naming, and Connecting CT Precursors To Curriculum

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City University of New York
College of Staten Island
Tuesday, June 13, 2023

EPK-2 • Exploring CT with PreK to 2nd Grade Teachers • Sean Justice & Lori Czop Assaf • Texas State University, San Marcos

Abstract: This presentation describes a 3-year study with early elementary teachers as they learned to integrate computational thinking (CT) within their established teaching practices. The study introduced teachers to CT with an inquiry-based, generative learning framework centered on tools and materials, aka “material inquiry”. After an initial CT learning institute, we observed teachers in their classrooms as they picked up and applied CT to their instruction. Among other takeaways, we have come to think of CT as a multimodal literacy rooted in everyday patterns of meaning making, or precursors.

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EPK-2

Exploring preK-2nd grade teachers' abilities to NOTICE, NAME, and CONNECT computational thinking to the curriculum.

Art • Science • Storytelling

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Summary of the Study

Exploring CT with PreK to 2nd Grade Teachers

A year-long professional learning program to facilitate teachers' CT learning.

First, teachers explored CT by making art, doing science, and telling stories within a professional learning community.

Then, teachers designed and implemented CT learning activities in their classrooms.

Kindergarten teacher prompting students to make a hide-and-seek game on ScratchJr.

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Summary of the Study

Research Questions

1: What do teachers *learn* while participating in a year long professional learning program on CT?

2: How do teachers *implement* CT in their classrooms while participating in the program?

3: What *mediates* teachers' learning while participating in the program?

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Summary of the Study

Process & Approach

- ❖ Mixed-method and ethnographic.
- ❖ Multimodal inquiry.
- ❖ Teachers were encouraged to implement their learning in their classrooms, but—
- ❖ Not told what to do or how to do it.
- ❖ CT as expressive and meaningful.

Light-up Thank You cards with paper circuits at the summer Institute.

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Phase 1: Computational Making & Inquiry Institute (Summer)

• Pre-Institute Meeting (3 hrs).
• 2-week Institute June 2021 & 2022.

Data

1. Pre/Post Survey on CT.
2. Field notes and teacher-produced artifacts.
3. Post-Institute interview.

Phase 2: Meetups and Teacher Observations (School Year)

• Scheduled classroom observations.
• Group Meet-Ups (Virtual & F2F).
• Individual Coaching (as requested).

Data

1. Classroom observations with videos.
2. Field notes, lesson plans, & artifacts.
3. Post Observation interviews and video recall.

Phase 3: Learning Conference (End of School Year)

• Teachers present their CT learning.

• Hands-on demonstrations.
• Poster sessions.
Data
1. Teacher implementation artifacts.
2. Field notes and videos.
3. Exit Survey on CT.

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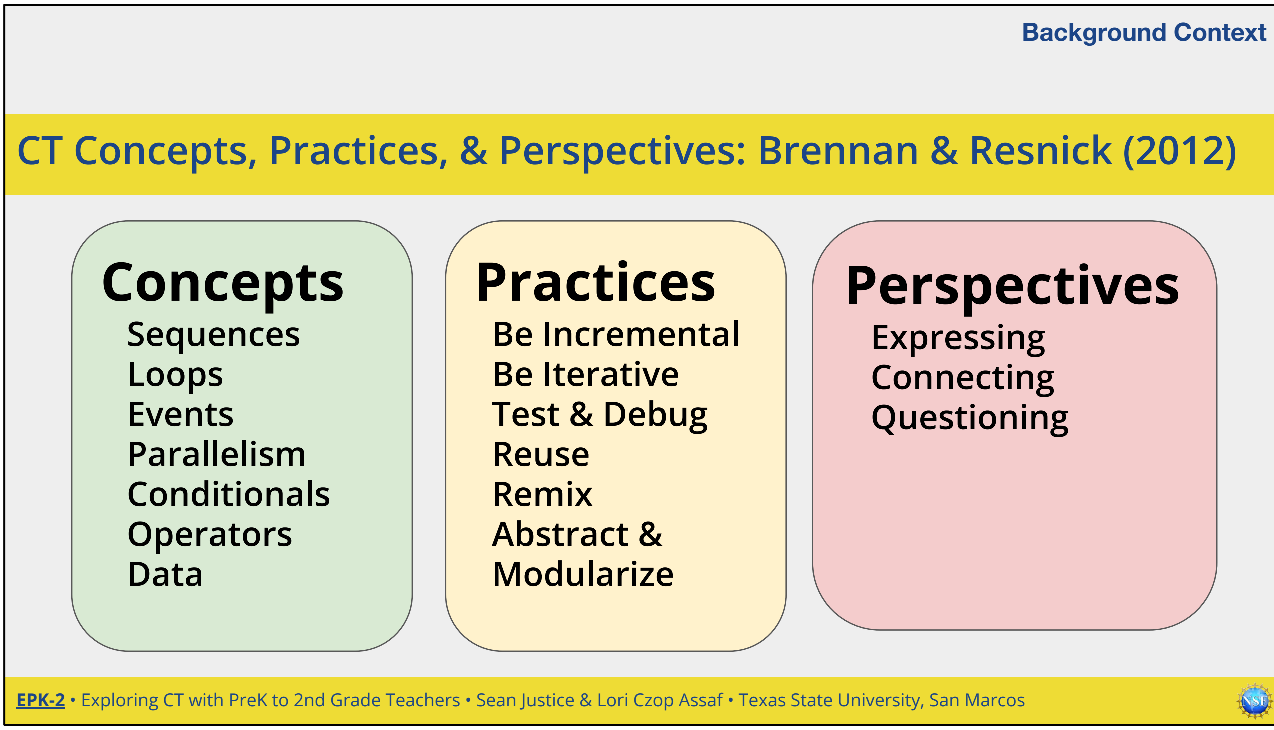

Brennan, K. A., & Resnick, M. (2012). *New frameworks for studying and assessing the development of computation thinking: Using artifact-based interviews to study the development of computational thinking in interactive media design*. In. AERA. https://web.media.mit.edu/~kbrennan/files/Brennan_Resnick_AERA2012_CT.pdf

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Background Context

CT Powerful Ideas: Marina Bers (2021)

Powerful Idea	Related Early Childhood Concepts and Skills
Algorithms	• Sequencing/order (foundational math and literacy skill) • Logical organization
Modularity	• Breaking up a large job into smaller steps • Writing instructions • Grouping a list of instructions into a given category or module to complete a larger project
Control Structures	• Recognizing patterns and repetition • Cause and effect
Representation	• Symbolic representation (i.e., letters represent sounds) • Models
Hardware/Software	• Understanding that "smart" objects don't work by magic (i.e., cars, computers, tablets, etc.) • Recognizing objects that are human-engineered
Design Process	• Problem-solving • Perseverance • Editing/revision (i.e., in writing)
Debugging	• Identifying problems (checking your work) • Problem-solving • Perseverance

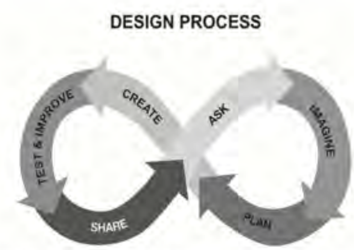

Figure 8.2 The steps of a simplified design process that can be used with young children.

from Bers (2021) *Coding as a Playground*. Routledge.

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Bers, M. U. (2021). *Coding as a playground: Programming and computational thinking in the early childhood classroom* (2nd ed.). Routledge.

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Background Context

Computational Thinking Is...	Important Because...
An emergent way of thinking brought about by programming computers while making expressive, meaningful artifacts.	CT is so broadly relevant to human life today that learning pathways should be available across the entire K-12 spectrum, applicable across all content areas.

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CT is:

A way of solving problems, and of finding problems worth solving; a mindset; a human way of thinking about and with computers.

The thinking routines and practices that shape and are shaped by computer programming symbol systems.

A participatory literacy, where participation creates and sustains communities of practice that include people working with computers.

A thought process involved in **formulating problems and their solutions** (Wing, 2017).

An **expressive and creative process** that includes dispositions, habits, and approaches while developing technological fluency. (Bers, 2021; Resnick 2017)

Concepts, practices, and perspectives applied by humans to express themselves by designing and constructing computation (Brennan & Resnick, 2012).

An **interdependent mindset or way of thinking** that emerges in the relationship between people and computational tools and materials (Resnick, 2017; Stephens & Edwards, 2018).

CT is important because:

Computational technologies are **transforming modern work and life** (Arnott, 2017; Stephen & Edwards, 2018)

Students learn to be good digital citizens, **recognize misinformation, and create better lives** for themselves and those around them (Pinder, 2022)

We need to **transform gender and economic inequities** that exist in computer science (Digital Promise Foundation, 2022).

Lack of research on the relationships between computational thinking, computer science, and literacies in early childhood education (Kafai & Proctor, 2022)

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Non-computational practices that might become computational thinking in the appropriate context.

With time and nurturing, learners acquire and refine the social, cognitive, and affective tools that sustain and expand communities of participation.

As with reading/writing; math; musical notation, early capacities can be thought of as *precursors* to practices that will later constitute mature capacities.

Precursors are *always already* present in learners' lives because they are ways of knowing and doing rooted in social participation.

- Precursors are non-computational thinking routines and practices that will become computational thinking with time, nurturing, and opportunities for tool/material exploration.
- The notion of *precursors* assumes that capacities for knowing and doing are rooted in social participation and therefore always already present in learners' lives.
- Foregrounding instructional design on precursors centers teachers attention on community building around socially valued content.
- For example, in the context of early childhood CT, teachers might learn to notice children's interests in pattern recognition or sequencing, among other participatory thinking routines, leading them to focus on what needs to be in place (in their classrooms, for themselves, for their students, for their school community) for young learners to refine the social, cognitive, and affective tools they need to sustain and expand communities of computational participation.

Photo Credit: Royalty-free photos by Pexels https://www.pexels.com/search/children/

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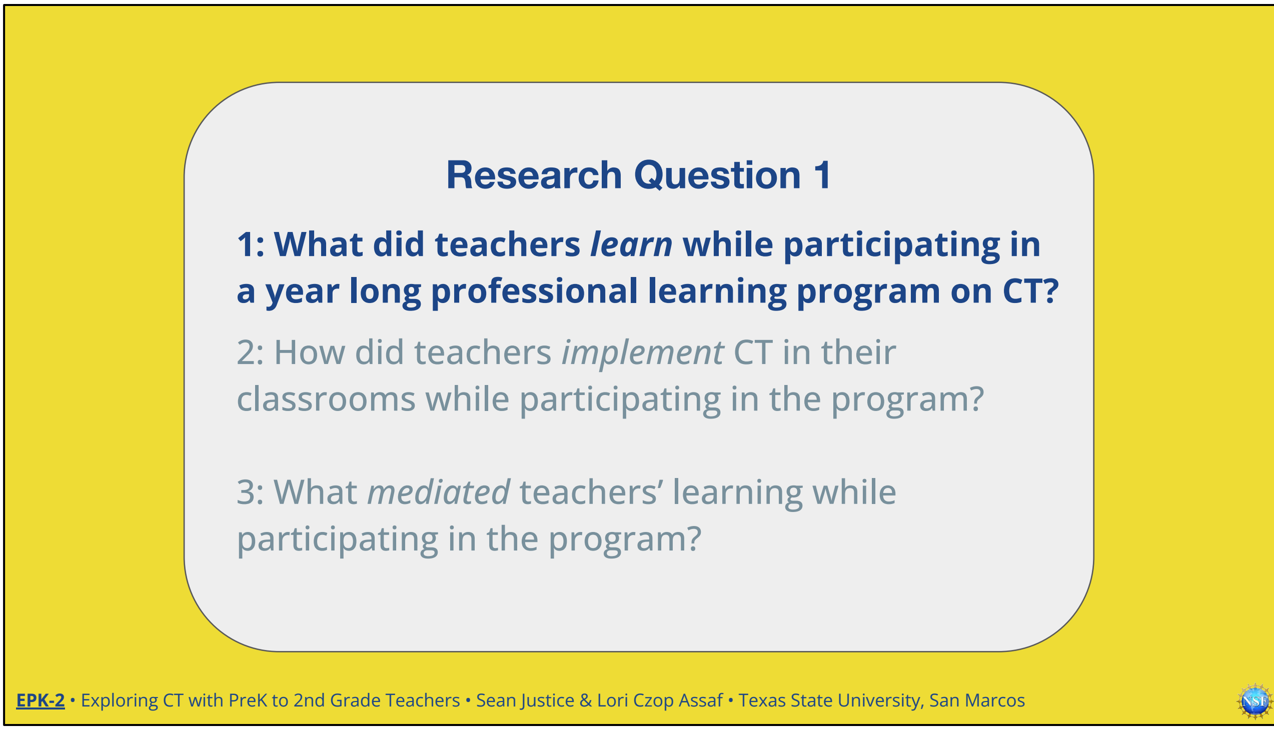

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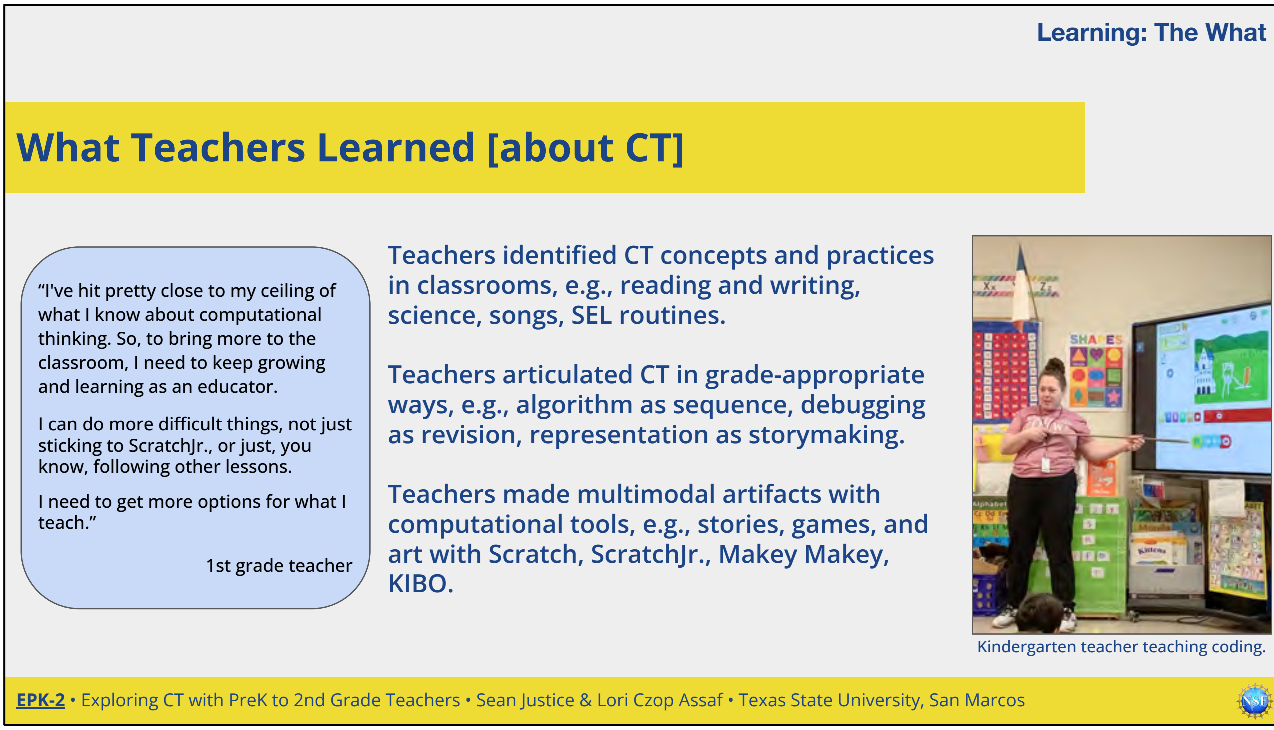

Pre/Post Survey analysis suggests *significant* changes in participants' beliefs across all four constructs: Coding ($p<.001$), Teaching computing ($p<.001$), the Value of computing in schools ($p<.05$), and Computational Thinking ($p<.05$). Validity of the revised survey also appears strong (Cronbach alphas: Coding .937; Teaching .957; Value .922; CT .838).

- ❖ **Survey:** *Teacher Beliefs about Coding and Computational Thinking* (TBaCCT) (Rich et al 2020); pre/post CMII; Revised for consistency; added dispositional short answer responses (Yadav & Berges, 2019).

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Learning: The What

What Teachers Learned [about teaching & learning]

Inquiry teaching became a driving force for how they learned, what they learned, and how they taught CT.

Teachers learned they could step back. They did not need to be the expert.

Teachers learned to support and inspire each other. They recognized their own willingness and tenacity for learning in a community of learners.

Teachers presenting for their cohort at the summer Institute.

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Learning: The What

What Teachers Learned [in their own voices]

"Let students take ownership of what they want to learn ...it's hard to let go sometimes as teachers. Maybe we have to let some stuff go."

"I wish I wouldn't have directed them because I feel like that's me kind of taking over. It's just really hard as a teacher not to kind of control things."

"I desperately want to grow with this, because ... I don't want to ruin their learning. Whenever you find something on your own and you learn how to do it, that's intrinsically woven into the fabric of your being."

"After doing the Institute and realizing I don't have to know everything to get started, and I could learn along with the kids, that was a huge mind-change."

"As a teacher you feel like you have to know everything."

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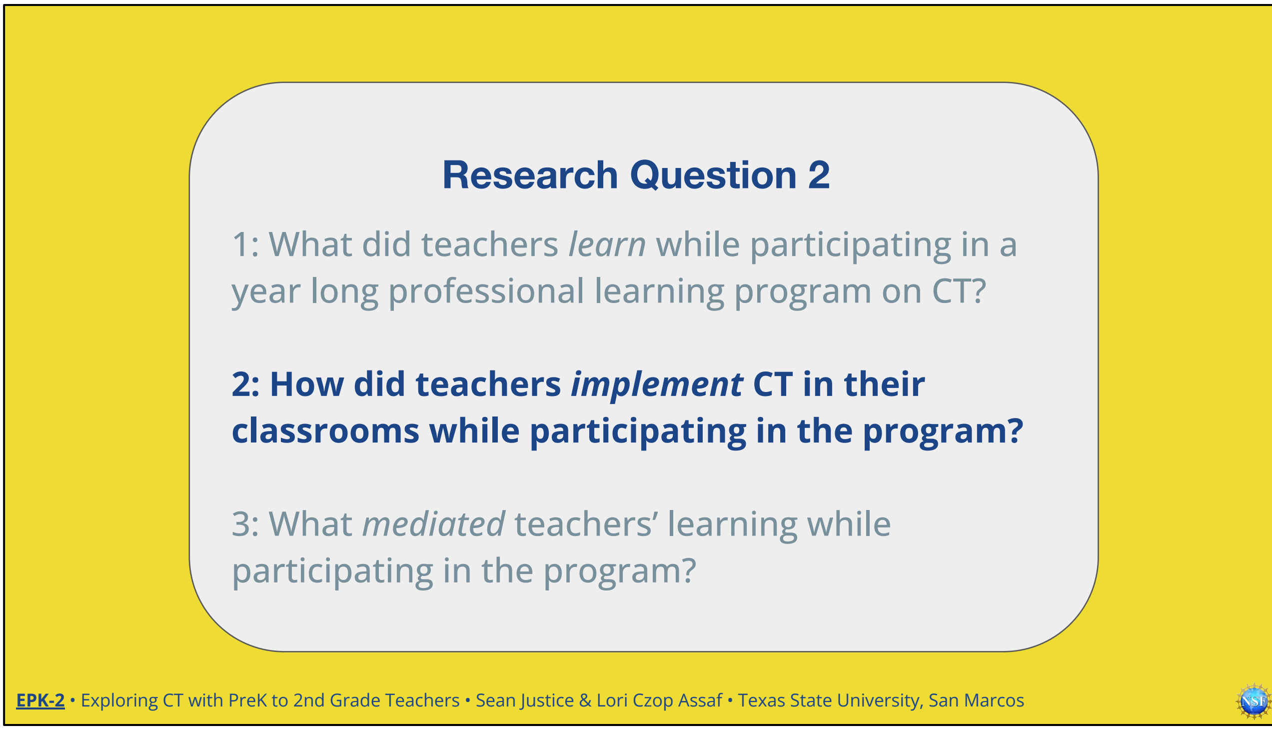

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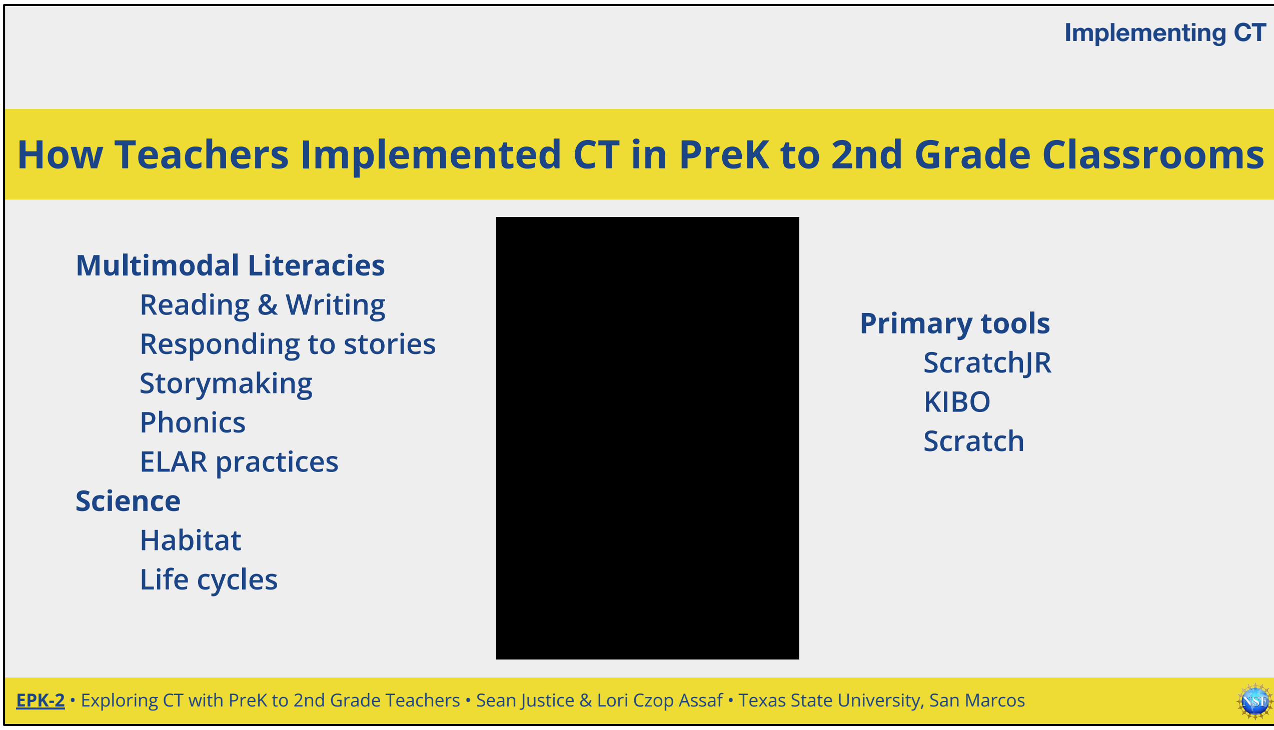

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Implementing CT

How Teachers Implemented CT: ELA, Story response

"In the fables and folktales unit, my group was working on retelling *The Boy Who Cried Wolf!* — beginning, middle, end.

Whenever I can tie in ScratchJr., I definitely want to do that.

With the fables and folktales, it just naturally felt like it worked really well for retelling."

1st Grade Teacher

1st grade story retelling activity: *The Boy Who Cried Wolf.*

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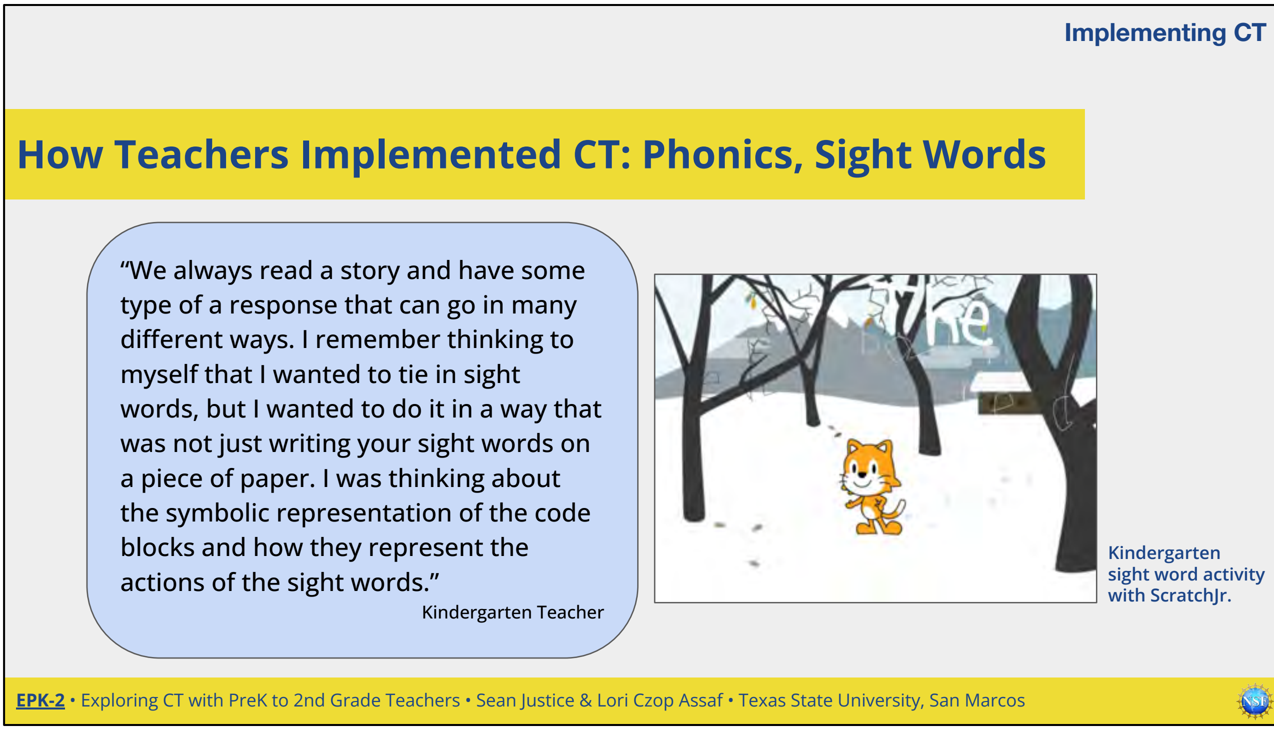

After reading How to *Hide a Butterfly & Other Insects*, by Ruth Heller (1992), Bridget asked her kindergartners to respond with ScratchJr., a block-based computer programming platform designed for early readers. Since the book focused on camouflage, Bridget invited the children to code a computational hide and seek animation with words that are difficult for young readers to decode, commonly known as sight words.

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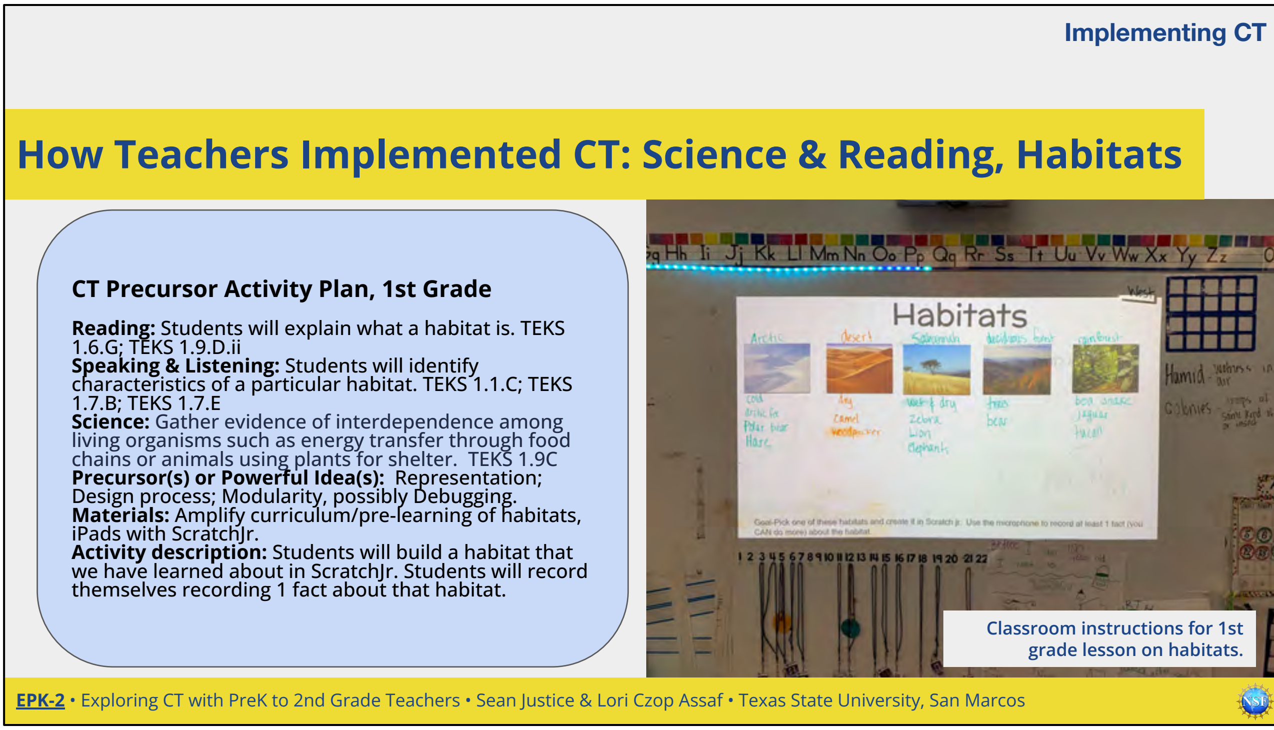

Excerpt from teacher interview:

"Yeah, well it was at, towards the end of our habitat unit where we had spent, I don't know how many days, it was probably 14 days learning about habitats and comparing them, learning about the animals and how to describe them, the environmental parts of the habitat adaptations, all of that. …

We actually only did one other thing … a research project about an animal. And so, it didn't have to be the same animal that they did their ScratchJr project on, but a lot of them did have the same animal. They had to read books about it, write down facts, record their information, and then turn that into a paragraph.

And got the idea because last year we were really focused on project based learning, and I wrote a unit for 2nd grade that was similar—it was using habitats and they had to plan out a zoo. With that one it was a lot of making using recyclable materials. They created the habitat and had to think about like oh, we don't want an African safari habitat next to, or an African savannah next to an arctic habitat, because there's such a degree difference in the temperatures, and they had to take that into consideration.

So, I kind of had that project in mind, but taking more technology driven piece instead of the recyclable materials and hot gluing. And part of that was because that project took like, two weeks. It took a long time for them to do it. And it was also tough to do in groups because everybody's like, "Well, who takes it home? I wanna take it home." "No, I wanna take it home." So, with ScratchJr, everybody got to have that ownership of their own project.

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Implementing CT

How Teachers Implemented CT: Science, Ladybug Life Cycle

2nd Grade Science
Life Cycle unit
Scratch

Requirements:
4 Sprites.
4 Screens.
Downloaded photos.
Complete sentences following given stems.

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Interview with teacher about this lesson:

Life cycle of insects … 2nd grade science … it was the start of a new unit and we finished it last week with the life cycle of a butterfly. So the week you were here was the life cycle of a ladybug. It's ladybug, grasshopper, butterfly, or other insects. My teammate and I both plan science. We decided on the ladybug for the first week and then the butterfly for the second week.

I thought the lesson overall was good, and after seeing your comment about you know, taking it maybe slower next time, I think that project maybe could have been broken up into like three days, maybe downloading images the first day, uploading them the second, and then starting the script on the third day. I know you can tell they're all different levels of understanding of Scratch. I paired them up based on who was here and who wasn't the day prior. Thursday we did a very small lesson over how to upload and download pictures, but we didn't upload them onto Scratch itself.

I felt confident because I created an example. So I went through it myself because, like even (a teacher who's not in the cohort) and I talk and we're like if we don't do it ourselves, how are they going to understand? So I think I mentioned to you that day, the night before and I created an example, a project myself of the actual end product.

Excerpts from teacher interview:

I started off with KIBO the way that we were introduced with KIBO where we had the smaller box. So, there's was a couple of blocks. It was the forward, backward, turn left, turn right, and then the parts just of the KIBO like the two wheels. And so, I started just with that. And really, I just gave them KIBO. We separated around the floor, and I just wanted them to figure out if they could find out how to make it move really. And so, I let them push buttons.

And then I started giving them some tasks. Okay. Well, can we make it move from this side to this side in a straight line, or can we make it move from left to right? And then there was another task. Can we make it shake? We got some shaking blocks and some light up – with the light bulbs. And so, there was just different – and gradually, more and more I had them add more pieces to it.

And so, in the beginning, I feel like students were very frustrated. I even had a new kid come in after students have already had opportunities and time with the robot that that student was frustrated even at the end because he didn't necessarily have the same time span as everybody else to explore with KIBO.

And so, he was frustrated and still is frustrated with ScratchJr because that's new to him as well. But for the majority of them, whether you were a low student, whether you were a speech student, whether you were a high student, they were all engaged and working together as a team to get their farmer to visit all of the animals. So, everybody had a piece. There was collaboration, working together.

My goal for this semester is that I want whatever it is that we're working in ScratchJr I want it to tie into Amplify. And so, today, for example, we were able to successfully do that with ScratchJr.

And the principal came in and was just so excited that we were able to get all the concepts that we've been working on, all of the – so, for example, it was like the little red hen last week. And then we started reading a book about ox and men. And so, they created the characters as sprites and they've just been taking off with it, and kids have just been engaged and just happy to be able to explore with ScratchJr.

And then I'm excited because it also ties into our reading curriculum.

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Implementing CT

How Teachers Implemented CT: Writing Processes

"The design process for computer programmers is about revising and editing. They check and check again until the code makes sense. And that is what we have been doing with our writing. Sometimes it takes many edits and many revising days until they get the right code for the computer."

Kindergarten Teacher

"Just like with reading and writing, writing is harder but reading is always easier. So, would it be easier to write code if they could read it?

But predicting of the code is one of the hardest things they do. They've gotten better—some of them can definitely predict the code. But they're just learning how to make those predictions in what they're writing.

Kindergarten Teacher

"See Through" videos.

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Excerpt from teacher interview (re: "revising and editing"):

I noticed first things like collaboration, because this is a year, where I've seen like way more collaboration than any other years. Engagement and I've also seen two were even like these students that struggle academically, like they are so engaged. And they want to try to do this, or they go in, with their friends because they want to do it- because there are so engaged.

So I have a student. I know this is recording so I won't tell you his name. But let's say his name is Pete. So, my student Pete struggles academically. There's so much going on at home and stuff and so he's struggling so much academically. But when ScratchJr. or crafts or any open ended material activities come in.. but like reading, man, he struggles to be engaged, like he's just—he doesn't stay on task at all, like at all. But during these activities like ScratchJr. and any open-ended material activity, he's so engaged. And he does not move until he finishes. So like I've seen that, like that student for sure. For sure he is so engaged.

(re: "predicting the code")

When we're working in ScratchJr, I feel like it's more open to your own interpretation of what you want your product to look like, so there's not really a that's not how you're supposed to do it, that's not right, it doesn't go there, why did you put it there, you know? And then just hearing the kids talk amongst each other, like their conversations during ScratchJr are always – not always but most of the time seem to stay on topic versus with the worksheet, they get distracted with anything that's happening, and a lot of times they're not talking about what the worksheet's about or what they're supposed to be doing.

But with ScratchJr, when that's happening in here, they're talking about what they're doing, they're asking for help about on-topic, they're engaged in what they're doing, they're having fun, they're giggling, they're laughing, they're sharing, they're up and moving around to show people versus with another type of response, it's more of like they're getting up and laughing and talking because they're off topic, not because they're actually working. So, I do feel like the environment definitely changes a little bit when we do an exit ticket on ScratchJr versus on a sticky Go Draw picture of the character. It is very different.

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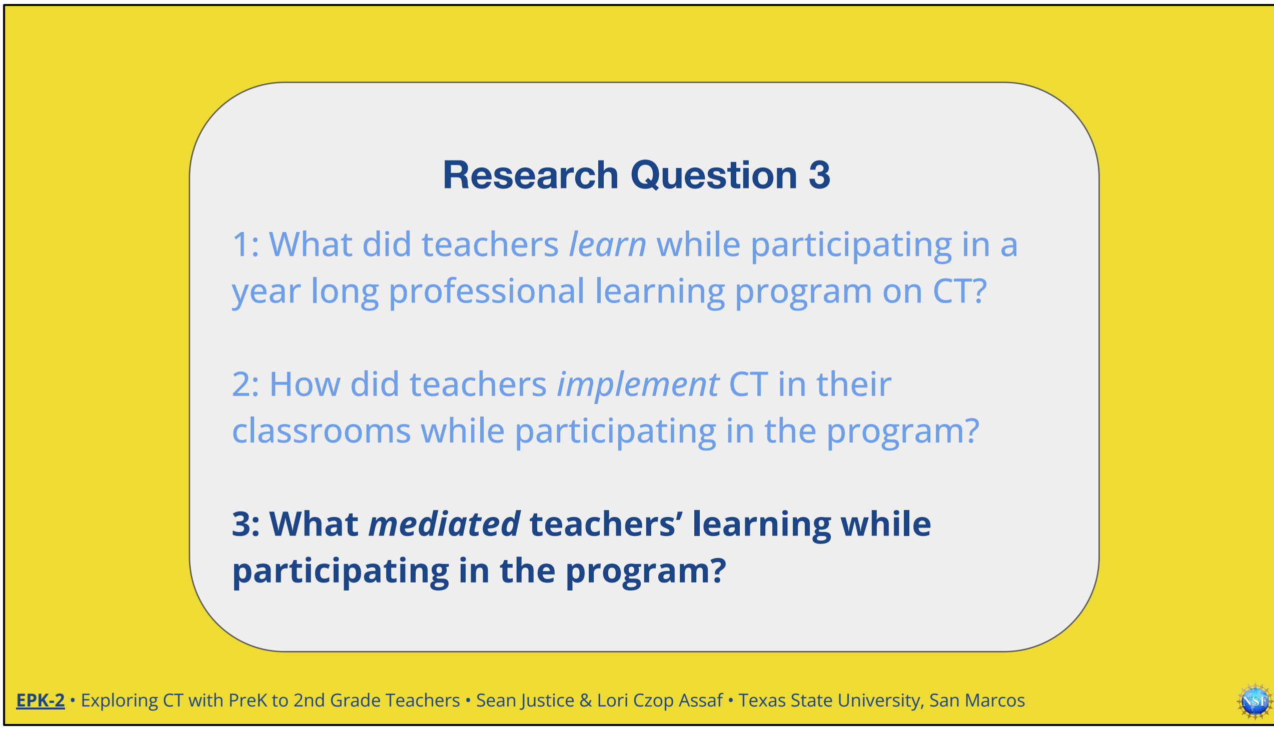

Abstract: This presentation describes a 3-year study with early elementary teachers as they learned to integrate computational thinking (CT) within their established teaching practices. The study introduced teachers to CT with an inquiry-based, generative learning framework centered on tools and materials, aka "material inquiry". After an initial CT learning institute, we observed teachers in their classrooms as they picked up and applied CT to their instruction. In my presentation I'll share what we learned about the way CT mattered and continues to matter to teachers, including examples of lesson plans and outcomes. Among other takeaways, my research partners and I have come to think of CT as a multimodal literacy rooted in everyday patterns of meaning making, or precursors. In this study we found that teachers who learned to notice and name those precursors were able to connect computational tools with interdisciplinary learning in their curriculum.

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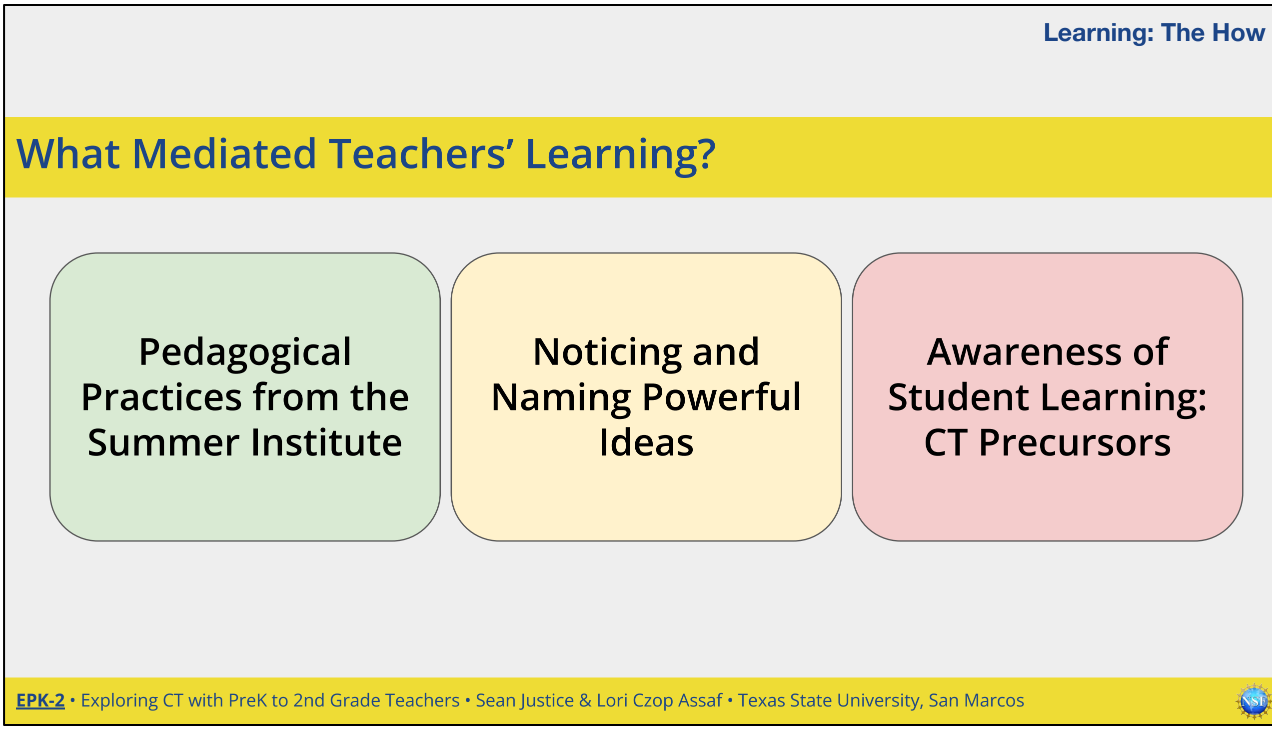

Footnote on Mediation

Sociocultural

For Vygotsky, mediation is a **core process by which learning occurs**—how the external becomes internal, and vice versa. **Learners rely on people and tools** to mediate their learning. Vygotsky positioned both people and tools as **essentially social**, because even when a learner is solving a problem alone, with tools, either physical or symbolic, those tools come from culture. (Taber, 2020)

Sociomaterial

Sociomaterialism **questions the positioning of tools and materials as neutral**, **stable, or in service to human intentionality.** Pulling from post-humanist critical theories, sociomaterialism argues that **tools and materials have agency and contribute unintended and unpredictable effects to learning**. (Hawley, 2021)

Hawley, S. (2021). Doing sociomaterial studies: the circuit of agency. *Learning, Media and Technology*, 1-14. https://doi.org/10.1080/17439884.2021.1986064

Taber, K. S. (2020). Mediated Learning Leading Development—The Social Development Theory of Lev Vygotsky. In B. Akpan & T. J. Kennedy (Eds.), *Science Education in Theory and Practice: An Introductory Guide to Learning Theory* (pp. 277-291). Springer International Publishing. https://doi.org/10.1007/978-3-030-43620-9_19

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What Mediated Learning?

Pedagogical Practices from the Summer Institute

- ➢ Teachers explored CT as expressive meaning-making practices by making art, doing science, and telling stories for themselves and each other.
- ➢ Teachers built interdependent understandings of CT as a learning community and began noticing, naming, and connecting CT to classroom learning activities.
- ➢ Teachers considered how and where CT might extend or support what they were already teaching (e.g., literacy, math, science, social studies).
- ➢ Teachers approached CT as an open-ended encounter with new tools and materials.
- ➢ Teachers' responses were not prescribed nor mandated. Teachers designed and implemented CT learning activities of their choice.

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Teachers were not asked to teach computer programming as a separate domain.

Teachers designed and implemented lessons of their choice.

Teachers were encouraged to consider <u>not</u> teaching computer programming as a separate domain.

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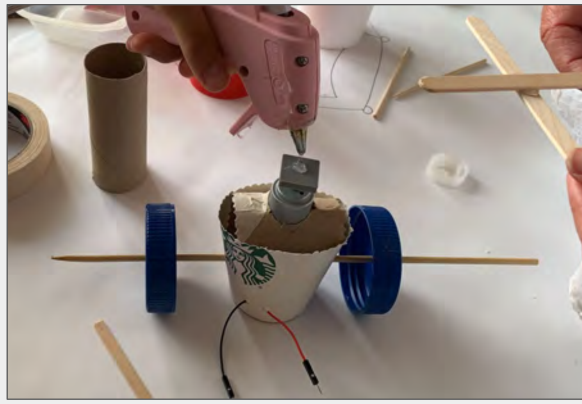
What Mediated Learning?

Pedagogical Practices from the Summer Institute [Activities]

Greet the Day Circle.
Tower of Hanoi puzzles. Bottle cap sorting.
Storytelling with ScratchJR, Scratch, and KIBO.
Make the cat move!
Animated Name Dance in Scratch.
Makey Makey narratives with KIBO and Scratch.
Interpretative mark making.
Mapping the way home. Retelling the map.
Mapping with Ozobot, KIBO, Edison.
Thank you circuits.
Art machines with motors & recycled materials.
Classroom games with Scratch.
On-site at Play & Inquiry preK summer school.
Collaborative reading: Bers'; Resnick; others.
Daily multimodal journaling.
Action plans for teaching with students.
Computing in the world videos: artists, designers, scientists.
Show and Share presentations.



Making art machines at the summer institute (click for a video).

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Footnote

Material Inquiry

"Lead with materials and listen for inquiry."

- Material Inquiry is rooted in generative learning methodologies, focused on:
  - Doing as knowing;
  - Serendipity; and
  - Enacted encounters with materiality.
- Material Inquiry activities begin with open-ended prompts that privilege process, not outcome.
- Material Inquiry design learning pathways that build interdependent community know-how and citizenship.

More about Material Inquiry:

The heart of Material Inquiry is something we call *material learning*. But talking about material learning is challenging because putting materials into words is difficult.

One reason for this difficulty is that the kind of learning we're pointing to is based on participation *with* materials, rather than working *on* materials. It feels counterintuitive to try to 'explain' something that is fundamentally experiential. It's like expecting a *description* of music to be an adequate substitute for *hearing* music.

https://www.materialinquiry.com/mi-details.html

See also: Cabral & Justice (2018); Justice (2015, 2016); Justice & Cabral (2013) (Citations in the References slides, below)

More on Generative learning:

Generative learning is a process of self-perpetuating change.

professional development program. Teacher learning becomes generative when they make connections with their students' lived experiences and then design instruction based on their professional knowledge, personal knowledge, and knowledge gained from students.

(Assaf & Lopez, 2015; Assaf et al., 2016; Ball, 2009, 2020; Brito & Ball, 2020; Liu & Ball, 2019)

In teacher learning, generative learning theory is conceptualized from sociocultural foundations, whereby the process of learning to teach is…

1. A generative social process mediated by language
2. in a community of practice,
3. where teachers collectively define, negotiate, and share stories about what it means to teach and learn.

(Battey & Franke, 2008; Danish et al., 2020; Wenger, 1998)

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What Mediated Learning?

Pedagogical Practices from the Summer Institute [Noticings]

"What did you notice about my project?"

"I think the whole idea, and something I want to do, is having the question, "What did you notice?" I want that question to be out there, really taking ownership of what they're creating."
Kindergarten Teacher

"I'm so appreciative of the 'I notice' statement that was shared during the summer, because that's helped me not be like, well, 'I see that you're doing this wrong'. It's like 'I notice that this is like this, how do you think we could do this differently?'"
GT Teacher

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Overall, teachers recognized and deployed inquiry methodology as pedagogical practice in their classrooms, mimicking the learning community they experienced in the summer Institute. To clarify, by adopting Material Inquiry methodology at the Institute, we evoked community space for collective sharing and the creation of community capital. Teachers told us explicitly that they strived to create similar social spaces in their classrooms, reflected in their seating arrangements, expert naming, noticing routines, and letting students move around to help one another, among other design choices. This learning community social structure was new to all of the teachers.

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What Mediated Learning?

Pedagogical Practices from the Summer Institute [Expertise]

Naming student experts on the white board.

Cultivating Community Expertise

“The summer helped me open my mind to try new things myself. I can have the kids be more comfortable in just exploring. I think in years past, I felt like if I’m not the expert, then maybe I shouldn’t be using it in my classroom, but that’s really not the case anymore, which is really cool.”

“These students were able to be experts, which was so powerful, because two of them are normally the ones that need the most help. They’re the ones that always say, ‘I don’t get it.’”

GT Teacher

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What Mediated Learning?

Naming and Noticing Powerful Ideas & Processes

Conceptual Frameworks

"I would call (the Powerful Ideas) sort of a tether. It sort of tethers me back, gives me a little bit of structure, a little bit of purpose, and a little bit of categorization, I guess, for how to think about what I'm introducing, what the core concepts are. I guess in that way, the powerful ideas give language to the almost indescribable things I feel like I'm saying at times."

Pre-Kindergarten Teacher

Examples of classroom reminders of CT concepts, practices, and perspectives.

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(At least) three ways teachers are naming and noticing the powerful ideas-

1. To define and model (within a non-tech or tech related activity)
2. **Theoretically**- without contextualizing in CT (i.e., as a way of reflection on non-tech projects & social interactions and problem solving processes (problems and solutions) [Taylor]
3. Powerful ideas **as a framework for learning** computational thinking (e.g., as literacy/language/vocabulary)

The process of noticing and naming the powerful ideas helped the teachers gain a better understanding of how these computational thinking skills and abilities **already exist in their classroom.**

[2nd grade Teacher]
And trial and error, I think it's like huge throughout this whole thing. I think our kids need more of that. It's like that's another kind of cycle that you go through. It's not just that you try something and then you're done. It's the same thing with our writing projects. They always say, "Oh I'm done Miss." And I say, "Well, let me read it. You missed a period here you didn't do this, and can you engage your reader?" And so teaching them that trial and error looks different for different things.

But, if we're talking about the powerful ideas, I would say like…Those are-I feel like the design process has been so like a big piece of this because....I think that the design process is connected because there's problem Solving but then they're also having to not give up. and keep going in the sense of, if something works or doesn't work, then how can we try something else.

[Pre-K teacher]
When we did the activity at the preK campus of putting up the posters that have the (powerful idea) words, the vocabulary that Bers uses. Those gave me specific terms that I can use to describe to other people, teachers and principals at my school, I can name what exactly the kids are doing,

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What Mediated Learning?

Naming and Noticing Powerful Ideas & Processes


1st grade paper circuits activity.

Modeling CT processes, such as debugging, with various activities: unplugged, low tech (e.g., paper circuits), or with computational tools (e.g., Scratch, ScratchJR., KIBO).

"I feel like there's a lot of trial and error and I feel as though the design process and debugging goes almost hand in hand because you're having to, well—what is the problem, why doesn't this work?"

2nd Grade Teacher

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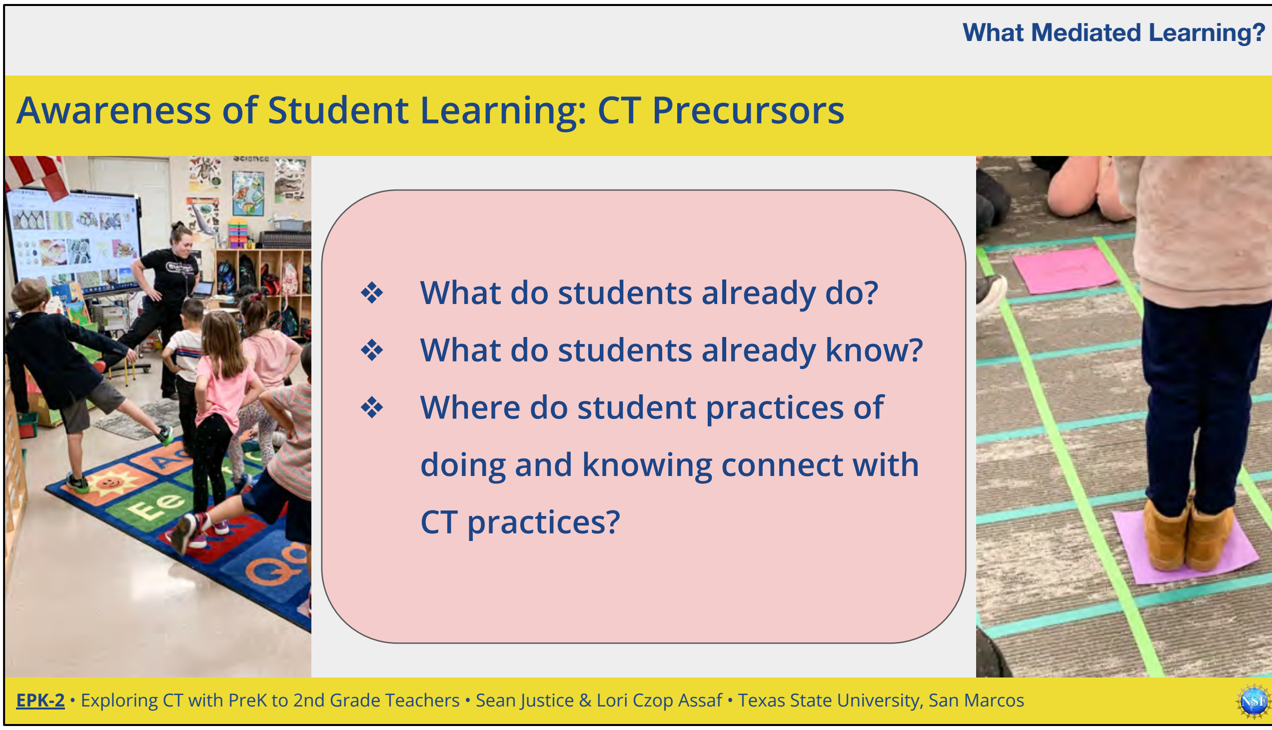

The notion of CT precursors helps us construct and articulate an additive perspective of students and their social, cognitive, and affective capacities (i.e., not a deficit perspective).

Noticing CT Precursors helped teachers recognize students' agency as interdependent with the world of peers, family, and community. Teachers realized they didn't have to work so hard to integrate CT in their classroom because it already exists—always already present in their students' lives. In response, teachers critically reflected on their teaching practice to embrace exploratory inquiry learning designs, for instance, by adopting the role of non-expert so their students could shine.

- Precursors are non-computational thinking routines and practices that will become computational thinking with time, nurturing, and opportunities for tool/material exploration.
- The notion of *precursors* assumes that capacities for knowing and doing are rooted in social participation and therefore always already present in learners' lives.
- Foregrounding instructional design on precursors centers teachers attention on community building around socially valued content.
- For example, in the context of early childhood CT, teachers might learn

- to notice children’s interests in pattern recognition or sequencing, among other participatory thinking routines, leading them to focus on what needs to be in place (in their classrooms, for themselves, for their students, for their school community) for young learners to refine the social, cognitive, and affective tools they need to sustain and expand communities of computational participation.

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What Mediated Learning?

Awareness of Student Learning: CT Precursors

Kindergarten brain break activity.

What do you notice?

Roll the dice to determine the gesture and the number of iterations: CT precursor concepts and practices.

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What Mediated Learning?

Awareness of Student Learning: CT Precursors

"I'm so glad I did not do my initial idea of the KIBO Corner with *my* algorithm."
Pre-Kindergarten Teacher

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Excerpts from teacher interview:

I feel like I learned that – I mean, I think there's two perspectives. I'm thinking of it in two different ways, because there's the way that I remember teaching it, and then there's watching the video that you took of me teaching it. And oh, my gosh, there's so many noticings that I had watching myself. I think that I was surprised, because I think a lot of it feels like I'm telling them to do this, I'm telling them. Like, "Oh, I told you. You have to start with this block."

But I don't feel like – watching the videos, I don't feel like I explicitly said that a lot. I feel like I let them make a lot of inferences on their own. I think I tried to guide them and I tried to remind them, like, "Oh, what block goes next?" I think I asked a lot of questions, and I kind of tried to generate more curiosity and more sort of interest.

Because I was wondering does KIBO actually come like that or is it something Dr. Justice designed. But as you noticed, I had taken different blocks from the big tub and little tub and kind of mixed them together and kind of made my own tub. And definitely, the thought of the algorithm was always in my head. The goal is for them to make a pattern, and we're focusing on colors, making a pattern with colors. So, the way I guess I thought of it was this is gonna be roughly the algorithm.

I let the clapping and the ear be a part of it, because I felt like that was – I don't know, it was just a way for the whole group to engage with KIBO at once instead of one person just pressing the button and KIBO doing it and kind of repeating that. They knew, and I think that that kind of helps build the algorithm in their mind when they have to do something physical like clapping. So, I took those blocks, and I kind of built a rough algorithm and said, you know, “I think that this is gonna work for my groups.”

And all the groups across the board, they were all very, very motivated to work with KIBO. And I set that expectation before we started working with KIBO that first week. “This is KIBO, we’re gonna be super gentle with him. We’re not going to press on him. This is what he’s used for. He is not a BattleBot.” And they wanna explore with KIBO. They want to learn with KIBO. Through all the groups, no matter how I differentiated the lesson, they were just excited to learn with KIBO.

And not only were they excited to learn from KIBO, they were all, I would say, successful kind of exploring with KIBO. Maybe not to the same extent. They didn’t get to the same level of advancement, but they were all successful in their exploration in getting KIBO to do what they wanted.

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Background Context

Why Precursors Matter to Teachers' CT Learning

Noticing CT precursors helped teachers teach from an additive perspective—where students' social, cognitive, and affective capacities might inform inclusive lesson design (i.e., not as a deficit perspective excludes what students always already know).

Once noticed, **Naming** CT precursors helped teachers recognize CT concepts, practices, and perspectives that students were already familiar with.

Connecting CT concepts, practices, and perspectives to what they were already teaching helped teachers understand they didn't have to work so hard at integrating CT in their classroom because it was already there—always already present in their students' lives.

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Discussion

Discussion: Constraints on CT Implementation

1) Curriculum: New, highly regimented, prescribed math and ELA at our partner district.
2) Hardware: iPad scarcity; Chromebook unsuitable; KIBOs fragile & scarce.
3) Competing CT initiatives: Internal and external.
4) Core vs periphery: FunFriday, Clubs, GT, Specialist.
5) Pedagogical biases: Exploratory inquiry vs directed instructionalism.

Each constraint has an uncertain and perhaps indeterminable bearing on questions around the design of a Generative Professional Development (GPD) program focused on CT.

Findings suggest teachers' learning is sparking their curiosity about CT, not for the sake of themselves but for their students.

Teachers are generally positive about the effect of CT in their classrooms and are figuring out how to make CT activities available to students.

Teachers express concern about students going into classrooms that do not invite meaningful engagement with computational tools.

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Discussion

Shaping Generative Learning & Implementation with Material Inquiry + Computational Making

Computational Making (Theoretical Frame)

Improvisational design practices that emphasize CT as an expressive, meaning-making process and that foster collaborative, participatory self-efficacy, even with beginners.

Material Inquiry Pedagogy (summer Institute instructional design.)

Material Inquiry (MI) is based on sociomaterialist frameworks focused on how tool/materials spark curiosity and a need to know. MI designs encounters with materiality in communities of learners to foster transformative learning.

Qualitative effectiveness

Teachers reported CT learning in interviews and demonstrated CT teaching in classrooms. All participants reported high engagement at the summer institute and most showed commitment to CT teaching throughout the study. Many participants also reported changes in their pedagogical practices and attributed those changes to the institute and other study activities, e.g., MeetUps, coaching sessions, etc.

Quantitative effectiveness

A survey of teachers' (N=23) beliefs about CT (Rich et al., 2020, TBaCCT [revised 2021]), administered pre-/post-institute showed significant changes across four constructs ($p < .001$; $p < .05$) with strong effect sizes (Cohen's d). For Cohort 1 (N=9), pre-institute/exit-program showed similar significance w/strong to moderate effect.

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Discussion

Computational Making & Inquiry Institute (CMII)

As **Generative Professional Development (GPD)** informed by generative learning theories, the EPK-2 Computational Making and Inquiry Institute (CMII) would most likely be **difficult to scale**:

1) Time intensive;
2) Required multiple follow-ups (e.g., MeetUps, coaching, etc.);
3) Relied on the cultural relevance of common goals within a community of learners.
4) Field must move away from quick-fix PD and instead invest in long-term professional learning that helps teachers navigate the curricula and contextual constraints and focus on students' learning needs.

Where do we go from here?

Further analysis of Cohort 1 & 2's generative learning in relation to the differences between the 2021 and 2022 CMII. What activities were most impactful? What aspects of the CMII can be trimmed or deleted?

Further comparative analysis of qual vs quant data. What is the role of the survey in understanding the mediating factors discussed here, e.g., noticing/naming, storymaking, structuring of learning in classrooms?

What is the role of a school or school-district in shaping cultural relevance and common goals? How might a school-based community of learners implement teacher leadership to support the interventions necessary to make day-to-day generative learning possible?

How do the changing definitions and contexts of CT affect expectations for CT in early elementary grades?

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Discussion

Effects of conceptual shifts > CT to CF to CL

Resnick has argued for **computational *fluency*** (CF) for more than two decades, positioned as expressive individual + community practices (Resnick et al., 1998; Resnick 2017): "Computers will not live up to their potential until we start to think of them less like televisions and more like paintbrushes" (Resnick, 2006, p. 192).

Kafai & Proctor (2022) have argued for expanding CT beyond its individualistic, cognitive limitations: "The purposes of **computational *literacies*** include not only an understanding of key [CT] ideas and practices but also its socially responsible and critical uses. (p. 147). Additionally, they have recognized the need to frame "computing as a vehicle for personal expression and connecting with others alongside and intersecting a plurality of other literacy practices" (p. 148).

Grover (2021) has argued that CT skills-learning is stronger when embedded in diverse content domains, both in CS- and non-CS classrooms, "***so that skills developed are conceptual and creative***" (p. 20, emphasis in the original). More broadly, (Grover & Pea, 2018), positioned computer science education as a **transdisciplinary domain without its own content**.

EPK-2 preliminary findings suggest teachers are starting to engage with computational tools and materials to augment and amplify meaning making in learning activities. The role of the CMII in combination with MeetUps and coaching is yet to be determined, but participants generally attribute these changes in their practice to the EPK-2 program.

Computer science education (CT/CF/CL) continues to evolve rapidly. And yet, EPK-2 participants find themselves in a system that positions computer science learning as emphasizing skills separate from meaning making (e.g., "TechAps"), without much explicit connection to community building or cultural relevance. For instance, a district principal told me this week that the district will emphasize keyboarding, because the Texas benchmark tests are now administered to 3rd graders only via computer

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Hunches, Musings & Theoretical Think-arounds

Teachers are not learning how to work generatively with computation (CT/CL/CF) for themselves, but they are facilitating it in classrooms. Teachers do, however, evidence some CT/CL/CF language (e.g., Bers, 2021; Brennan & Resnick, 2012).

In spite of survey results suggesting significant changes with strong effect sizes, pre- and post-institute, what seems to matter more than the CMII are teacher connections with each other, e.g., school leadership groups; principal support, community MeetUps, outside agencies, and funding initiatives.

Some participants have not evidenced strong buy-in for teaching with computational materials. Would they have had stronger buy-in if the focus had been directed more exclusively to community building—since schools are stronger than cohorts?

Naming and noticing powerful ideas appears a preferred way for doing CT. But, will schools stop at the naming? When computational tools and materials appear, teaching gets messy because it requires planning and actually doing something with the tools/materials, not just thinking about it. Teachers say, "But isn't *thinking* about computational thinking the same thing?"

What comes next? Focus on a whole school's generative learning. Look for the Material Inquiry effect. Does GPD centered on CT/CL/CF transform instructional practices in computational as well as in non computational activities?

Study to come: Whether computational tools and materials strengthen learning and community when contextualized as *fluencies* (Resnick, 2017) and *literacies* (Kafai & Proctor, 2022).

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Appendix

Ten Principles for Making Material Inquiry

1. Invite responses to multimodal text(s) as an experience of meaning making rather than as an exercise focused on tool use.
2. Encourage exploration of the way different tools and materials express differently, e.g., hard graphite vs soft charcoal; fast, skittery motion vs slow, smooth motion; looped percussion vs continuous melody; interactive touch via the keyboard vs a handmade interface collage.
3. Facilitate collaborative interactions between learners and story elements or domain prompts by focusing on interpersonal relationships, e.g., rather than focusing on simple appearances, ask, “How would it feel to be in this setting, or with this character?”
4. Minimize instructional talk to allow time for exploration, iteration, and purposeful play with examples, tools, and materials.
5. Maximize multimodality of learning resources, e.g., demonstrations plus videos, plus handouts, plus websites, plus instructional manuals, plus safety data sheets, etc.
6. Design participant-led show-and-shares that emphasize noticing instead of assessment, e.g., after sharing their work, learners ask each other, “What do you notice about my project?” — not, “What do you like?”
7. Arrange the classroom or studio with large tables instead of individual workstations to enhance learners’ interactions with each other.
8. Share models and examples instead of step-by-step instructions.
9. Make sure tools and materials are visible, plentiful, and multimodal, e.g., digital, computational, and traditional craft or fine-art.
10. Intersperse reflective turn-and-share moments with uninterrupted making and building.

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From

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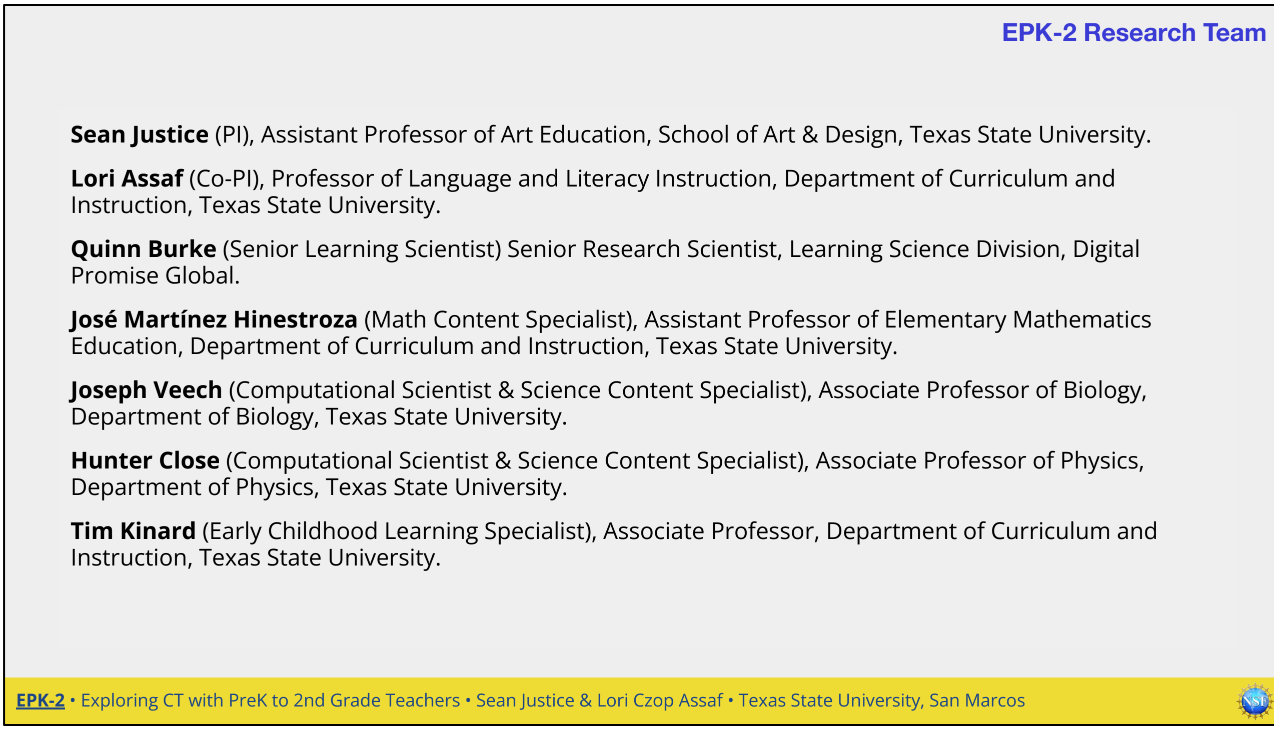

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EPK-2

Exploring preK-2nd grade teachers' abilities to NOTICE, NAME, and CONNECT computational thinking to the curriculum.

Art • Science • Storytelling

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