THE BROOKINGS INSTITUTION

WEBINAR

PROMOTING HIGH-QUALITY K-12 STEM INSTRUCTION TO PREPARE STUDENTS FOR THE FUTURE

Washington, D.C.

Tuesday, June 10, 2025

PANEL DISCUSSION:

LATRENDA KNIGHTEN
President, National Council of Teachers of Mathematics

JENNIFER CHILDRESS SELF
Program Manager, Science and Engineering, WestEd

JOHN PECORE
Professor of Teaching, Leadership, and Research, University of West Florida
President, Association for Science Teacher Education

MODERATOR: MICHAEL HANSEN
Senior Fellow, Brown Center on Education Policy, The Brookings Institution

* * * * *

HANSEN: Good afternoon, everyone. I'm Mike Hansen, senior fellow in the Brown Center on Education Policy here at the Brookings Institution. Thank you for joining this afternoon's Brookings event on Promoting High Quality K-12 STEM Instruction to Prepare Students For the Future. America's future economic opportunity, international competitiveness, and national security are all reliant on young people's mastery of STEM. So these are science, technology, engineering, and math subjects. You have very strong headwinds ranging from the pandemic learning losses to increasing student engagement, they have thwarted K-12 students' progress in these areas. Meanwhile, technological advances around artificial intelligence or other technologies offer both opportunities and new threats, creating uncertainty about whether and how STEM instructional models should be shifting for the future.

What can school leaders be doing to support high-quality STEM instruction across all classrooms, and what can state policymakers be doing to ensure high instructional standards are upheld? Today, I'm joined by three esteemed panelists with a variety of perspectives on STEM standards, curriculum, and instruction. They are, first, Latrenda Knighten. Latrenda is President of the National Council of Teachers of Mathematics. Latrena has over 30 years of experience as an educator, working with students and other teachers to improve their math instruction. Next, we have Jennifer Childress Self. She is Program Manager of Science and Engineering at WestEd, a nonpartisan research institution. Jennifer has 20 years of experience in science standards and instruction, and currently serves as Science Review Lead for NextGen Science.

And finally, we have John Pecore. John is Professor of Teaching Leadership and Research at the University of West Florida, where he has led the university's Robert Noyce Teacher Scholarship Program. He also serves as President for the Association for Science Teacher Education. We'll get to the panel discussion momentarily, but before I must know a couple of items. Number one. We welcome audience participation during the Q&A portion of this event. Those listening in can submit questions to the panelists by either sending an email to events@brookings.edu, that's the word events, E-V-E-N-T-S@brookings.edu or by using the hashtag stem instruction on social media. We'll be monitoring both.

And second, I also want to acknowledge that funding from the National Science Foundation, grant number 1950284. Is supporting this webinar. This webinar is the second in an event series on STEM teachers and education that we are now conducting. And please mark your calendars for our next and final event, which will be held the afternoon of Wednesday, July 16th. So without any further ado, let's jump into the discussion. I'm first gonna turn to Jennifer. Jennifer, you've been involved in the process of creating STEM standards that are now widely utilized across states. How do we translate these high standards into successful STEM instructional practices in the classroom? And what do you see as the key bottlenecks to strong implementation?

CHILDRESS SELF: Thanks so much, Mike. I'm really honored to be here with all of you today. And it's actually pretty exciting that we can even talk about STEM standards that are widely used across states, because it's really only in the last 15 years that we could even have this conversation. So specifically in science, as of last year, we now have 49 states that based their content standards on the framework for K-12 science education from the National Academies. And that document outlined the research on how people learn, showing us that teachers are most effective when they're positioned as expert facilitators of student learning, rather than as lecturers who deliver information.

And it showed us that students are most effective as learners, just like the rest of us as adults, when they see the relevance of what they're doing in the classroom, and they know that their own ideas are respected and valued by their teacher. But that way of teaching and learning that's in these state standards is very different from how most adults experience school and how most teachers were trained. So what we have now in many states is a gap between the inertia that exists in the education system and this new vision of teaching and learning that we see in the standards. So as you mentioned, Mike, we still have to translate those standards into classroom practice, trying to close that gap.

And that means changing the expectations of students, teachers and administrators, changing the way we support and prepare teachers, changing the textbooks that we use, changing the assessments we use changing the ways we work with families and community members. And It's a lot of work. States and districts are really just beginning this long process of change and, you know,

some of those states just adopted their new framework-based standards within the last couple of years. So it's going to be a while before we actually see full implementation. And in the education field, we know we're pretty good at starting new implementation efforts. We always have a thousand flowers blooming, but we're very often less successful at sustaining and scaling. The change long term.

So I mean, we know that attention and personnel shift all the time in school districts, which really rare to get transformed materials, training and supports for every single STEM teacher in a district and to get the commitments from the district leaders to continue supporting the professional growth of all of those teachers and their school leaders every year, but it can be done. When the leaders are committed to the change and they decide to align all parts of the system, we can see real sustained change.

HANSEN: Great, thank you, Jennifer. I appreciate that perspective. John, next, I wanna turn the conversation to you. You are in the process of training the next generation of STEM teachers. And as Jennifer just mentioned, there's a lot of training and sort of shifting that needs to happen. What are the key ingredients that you want to pass on to these teachers in training so that they can succeed in the classroom?

PECORE: Well, so yeah, following up on what Jennifer said, it was interesting. I started my teaching career over 25 years ago. And at that time, this hands-on inquiry learning was the way we were taught. And what we're finding when we go out in the classrooms today is the same old stuff, especially in some of the courses that are tested in science like biology. We find a lot of PowerPoint lectures when we go in there. So that shift, that change is really, really challenging. And interesting enough to follow up on that as well, Florida is going through their revision of their science standards this year. So they completed their math standards, which I think incorporated a lot more real world activities and things, but not to the degree as of what I like.

So, to get to your question, one of the things is we talk about real world, and I like to frame it in real world according to the student and the student's interests, not real world in terms of what we as adults

see in the world, but what do students see in in the real world and how can we connect the content to the students lived world or real world out there. And I think with the emerging of virtual reality and AI, that's gonna be an interesting shift. I'm working with a colleague in Texas on a project where we're having students use AI to help them design more creative lesson plans that are more real world and use more active learning techniques. So hopefully that will help this. These teachers that are coming in to design more creative lessons that align more with the new science, the standards, the three dimensions of the NSTA standards.

HANSEN: Great, thank you, John. I appreciate that. You touched on VR, AI, those are really hot topics, and I know we're gonna have a discussion around those towards a little bit later, but first I wanna bring Latrenda in. Latrenda, discussions about STEM instruction are often focused on middle and high school grades, but I understand you take issue with that premise. Please share with us your views about the right time for STEM instruction.

KNIGHTEN: Hi Mike, thank you again for inviting me to be a part of this panel, and I guess I wholly agree that STEM opportunities should happen for students across the entire pre-K-12 spectrum. And so one of the reasons I do like to point out some specific things about where should begin is I know in my own experience as a student that I was exposed to more math and science in my secondary experience as opposed to my elementary experience. But when you know better, you should do better. We always say that. And so we have a full body of research that shows us that early math skills are a huge predictor of student interests, confidence, and success. Math achievement later in life. And so I say this because we know that very young children are naturally inquisitive, they're naturally curious, and they're primed for all the inquiry that we really need when we start thinking about those STEM skills.

So one of the things that I noticed when I left the classroom setting and worked at a district level with looking at all in all teachers pre-K-12. That we were missing the boat for a lot of students. There were a lot of miss opportunities because when we ignore those STEM opportunities in the early grades, we have an entire segment of students who are not being exposed to that critical thinking, the problem solving, the reasoning, all of those things that we're looking for students to be able to captivate and

make the most of in those STEM courses. And so what happens is for some students, They're counted out of those opportunities because they're missing those foundational opportunities, those foundational skills.

So what I like to remind educators and whenever I get an opportunity to talk to the decision makers, those people in the district office who are making decisions about what is happening in a system when they look at math and science for all students is to make sure that those STEM opportunities are present. In the elementary grades and the foundational grades. We have to give all students an opportunity to have access to those type of activities, to that learning, to that content. And so what happens as a result, students are building those early numeracy skills, they're building that foundational knowledge, but they're having an opportunity to problem solve, to reason, to use critical thinking. And so as a results, They're more engaged in that process. So they see opportunities that maybe they wouldn't see if they're just sitting and listening and watching others interact with the content.

And also we're building student confidence. So as students become more confident in themselves, they feel as if they are learners and doers of mathematics and science, students are going to want more opportunities to engage in those activities. And you have more students who are able to actively participate and engage and take part in those activities when they move to middle and high school. So you don't really see those struggles that some students go through because they don't have the foundational knowledge or even the interests or know that there's this world out there for them. So I say that we should look at this as a pre-K-12. Activity or exposure, not just for students when we start thinking about their career post the high school experience. Thank you.

HANSEN: Great, thank you, Latrenda. Those are some really important comments and talking about leveraging the children's, especially young children's natural curiosity to really propel them to start thinking like scientists. I love that. And so all three of you have now discussed the importance of hands-on practical experiences, getting them engaged, helping them to see those applications. But what does this mean in practice? You're describing, Jennifer, you're describing that teachers need to be approaching this differently and approaching instruction differently. Is every day now lab day?

Is every sort of going out in the field and collecting new data? Or we're never doing any lectures? Or what is the optimal mix of instruction styles look like? And do we have any research to really point us in any direction here? I think all three of you probably have some perspectives on this, so why don't I first go to Jennifer on this?

CHILDRESS SELF: Yeah, thank you. I think it's really a shift in how we think about STEM learning instead of thinking about this tension between the lectures versus labs or practice problems. The research on teaching and learning. It really focuses on preparing students to succeed in a future where they need to think and solve problems. So at least from the science side of things, because that's my, my main area. Although I'm dabbling in math, I'm at a math conference today. But for science at least, it means contextualizing all student learning K-12 with real world problems to solve or what we call phenomena. So like looking at water on the outside of a cold glass. So students still have to do lectures or have lectures, they still have do labs depending on what they as a class determine is the next best step.

To figure out the solution or explain the phenomenon. So it's less a focus on specifically what their hands are doing, more what their minds are doing. And so the teacher can then facilitate them to realize there's a gap in their knowledge that they need to fill and that the class wants the teacher to provide some information through a lecture or through a reading, or they have a hypothesis they wanna test in a lab. So they still need to learn the facts and concepts, but they just learn them for a reason that they care about. And that keeps them engaged in the learning and ensures that they actually retain the information long-term.

HANSEN: Great, thank you. How about John, why don't you hop in here, tell us about how are you training teachers and encouraging them to teach in the classroom?

PECORE: Sure. My main research focus has always been in related to project based learning or experiential, a form of experiential learning. And I've really gravitated to project-based learning early on and when I was teaching middle school and high school. And that's what I focus on in my course with my student teachers. So The difference I see though, and it kind of follows up on what Jennifer

was saying, I like water, but rather than like water on a glass, I kind of like thinking, how can we take students outside to investigate a project? So one that I collaborated with a biologist at the University of West Florida early on was on something we called the Lionfish Project, where we had some professional development for biology teachers to come in.

And we taught them how to dissect the lionfish after, of course, we took off the poisonous spikes, but how to the line fish, how to get their students to, so they could do this project with their students. Dissect them, go into the stomachs, take out the digested prey. We do DNA sequencing and analysis on it. The students, we send them off to the lab. The students then get those results. And put them into a database. So it's sort of a citizen science project. And so projects kind of like that, that we try to gear that, you know, I said earlier that the projects should be of real world to the students and of interest to the student. So, and that's sort of the goal is how do you come up with a project that students will be engaged and interested in. Another one is, here in Pensacola, they were designing a skate park underneath the interstate.

And so we challenged the students with, you know, math students, how would you design the skate park for it and what would you do in presenting it to the city council. So projects like that is the way I like to try to get students engaged. And that doesn't mean... Totally with doing away with things like a lecture or something like that. I like to call them mini lectures where I keep them down to about 10 minutes because we know the average attention span of a lecture is probably about 10 minutes. So, you know, when I notice the students are struggling in a certain area or something like that, then take a little I call them a little these little mini lectures. And I even had to have students time me and say, you know, yeah, time me, time when 10 minutes is up and I'll stop the lecture. But getting them that scaffolded support that they need and just in time and when they need it to be able to further their progress on the project and learn.

HANSEN: Thanks, John. So now this sounds great, especially for students who are in late high school into college even. But I think of many elementary age teachers in particular would be curious, how might this look differently for those younger learners? Latrenda, I really appreciate your

perspective here. And I'd like to hear how you are thinking about that and applying some of these principles.

KNIGHTEN: You know, that's a really interesting question. You know I have to say when John mentioned his intro when he talked about his years of experience and that how we're talking about how we should teach is how he was taught to teach. And that's what I tell people all the time. I have been doing this for 32 plus years, and I was taught teach this way. And so I don't understand why we're still shifting, or some people are just beginning to shift. But the reason I say it's an interesting question because it made me feel really good to hear the things that Jennifer and John were both saying because there was a time when I first started teaching and I taught this way that the things that they're talking about that we want to see from teachers and the things that John is mentioning that he does with his own students and with the adults that he teaches, there was the time when people thought you only did things like that with young children.

You only did inquiry with little children because when you move to secondary, that's big school. So you should be reading books and writing papers and just sitting in rows and listening to the teacher tell you everything. And so what I say to teachers who teach young children, especially those who teach the youngest, who say, oh, well, my kids can't do that. They can't work independently. You know, yes, they can. Because students... Come to us with so much knowledge and so much information and so it's that shift as Jennifer was talking about the shift when we think about the standards and we think about the pedagogy it's the shift from the teacher moving from I'm imparting all knowledge to I'm being the facilitator so what it means is trusting the process but also having you know those support networks I know we'll talk about that a little bit later as well But thinking about that student-centered classroom, because one of the things that is common in everything that everyone has said is the relevance.

All students need to see relevance in what they're doing. And so that's very young children, as well as students when we move to those middle and high school grades. And so, that means teachers learning how to be a facilitator, where you may, We call it lecture at the. Old upper grades, but you balance that time between when you are actually the person who's doing the talking with the time that

the students are talking. The students are initiating things. And so even in the very young grades, we use in science, like the driving question boards, where students have that question that governs the inquiry that we're looking for that week. And so you're thinking about what are all the things that you're that are related to that. So thinking about students being actively engaged, how they're making connections, how does it make sense?

So maybe for young students, maybe if they walk to school and they see stoplights or they see different things that happen along their short walk to the school, what are some things they can think about that affect that particular environment? What are some thing they can do to improve that experience? So that might be something that's very cognizant to them. What about the playground? Are the balls bouncy enough? Can they do a test to test the bounciness of the balls and decide which ball has the most bounce? That was something we used to do in first grade as a science unit, but we also did it as part of math as well, because there's so much STEM involved. If you're going to give advice to someone who was designing these balls for the playground, what would you tell them to do to make these more effective?

So you think about students, you think about relevance of interest to them, and you ask them. You allow them to have input. And so you use that as your avenue. And one of the things I tell teachers, I teach very young children who are very reluctant to give them that independence, is one of things you can do is teach yourself to be an observer. So if you're not really good at facilitating or you're just learning. Carry around a notebook. And so set those timers so that your students are doing most of the talking. And while you have that notebook and you're walking around, you're writing down what your students are doing. So you're looking at what they're doing, you're making observations, you're posing a question or two so that students will be prompted to think about something else, providing necessary scaffolding.

But once you start to do that, you really begin to see a lot of the brilliance that students have. And you begin to get ideas of how you can do this on an ongoing basis. You learn how to become a teacher who promotes inquiry and a teacher, who serves as a facilitator and uses your students as like a sounding board for what's the next exploration. How do you make those connections? So that would

be my biggest piece of advice to give to a teacher. Who's reluctant to like to give up that control. Is to have that notebook and write. So you have something actively to do, but your job is to observe, make notes, and intervene and ask questions as needed.

HANSEN: Thank you, Latrenda. I want to piggyback off of that, and I also want to take this conversation into a sort of one of two different directions, and you can decide which way we're going here. So if we're thinking of teachers as facilitators of learning and experience sort of curating the experiential opportunities for these kids to apply principles of math science or whatever STEM field they're in. There's two related questions here. So number one is, are we doing enough to ensure that the teachers have the adequate professional development to make sure that they're delivering that?

And then number two, we all know that there are a lot of equity challenges around making sure that all teachers are supported and it's not just sort of the teachers who are in the. Adequately resource schools that have, you know, these kinds of great learning experiences. How do we ensure that everybody is able to deliver on that? So there's sort of two different strands. They're they feel different, but they're also intertwined and related. So professional development and equity and access to strong learning. Um, any thoughts on that one of the first go to John here.

PECORE: Um, yeah, definitely. I think, um, you know, I taught a couple of years at Temple University and there when the students were in their STEM classes, so they were taken chemistry and their chemistry in their math classes toward their degree, there were several of the courses which were inquiry based, which, um so the chemistry class, I remember where they made like beer and wine or something. So it was very real world relevant, and they learned the contents through a project, you know, and experiential learning. And I find I found students that kind of anecdotal didn't do a full research study on it.

But I found the students there who had gone through those types of experiences were much more willing and much more able to do more of these project based type lessons in when they got into teaching. And there's so I think the more. The more experiences they have, the more we can provide them with them being actual learners through this type of a learning environment. And the more they

can watch it, the more can observe it, the better. You know, I mentioned, I'm gonna go back to the virtual reality right now, because I spent a year teaching at a virtual reality school. And so that provided me with an opportunity to engage and immerse in teaching in virtual reality, which at the time I was like... Big skeptic of it but then at the end of the year sabbatical was okay this this has a lot of potential so my latest NSF funded project hopefully will be taking our pre-service teachers into a virtual reality environment where they're working with students in a socio-scientific issues.

So trying to get them to facilitate discussions with students, avatar students in this virtual reality world, to give them that practice, to give that experiences in there, so. And in terms of the equity and access for all students, we need to be conscious of making these resources available to all of our teachers, especially those that are limited in access to these types of learning experiences.

HANSEN: Great, great. Thanks, John. Jennifer, your thoughts on the intersection or interplay between equity issues and professional development for teachers here?

CHILDRESS SELF: Yeah, well, actually the conference that I'm in right now is I really love this model. They're bringing together education prep programs with the districts that they primarily serve and having them open the lines of communication. And I think that that's one avenue that doesn't often get explored. They are not necessarily fully aligned. Especially when we're talking about the public schools that serve the most disadvantaged students. There just aren't, you know, the funding, there isn't, there's other competing priorities, all of the challenges that we talked about earlier. And this is one of the reasons I care so deeply about public education, because when we focus on those fundamental system lovers, Um, things like the curriculum, like the teacher training, um, like the administrator support, then, uh, we are actually improving instruction for all the students who need it the most, right?

The, often the most disadvantaged students. And, um. So when. You know, when there can be good connections between the teacher prep programs, when there be a real commitment from leadership to support teacher training, to make sure that that professional learning is curriculum embedded, curriculum based, with high quality instructional materials provided to the teachers and supportive

communities and those instructional leaders. Get the training that they need to continually grow in their instructional leadership, then we can actually see improvement.

HANSEN: Thank you. Thank you, Jennifer, sort of on this topic of equities. I have an audience question here. I want to read off Barbara Newhall of Penn State asks, what are some ways we can increase stem interest among young black female K-12 learners? According to recent research data, their data their interest, excuse me, is low compared to their peers of a different race or gender. Latrenda, do you want to hop in on this one?

KNIGHTEN: Sure. And this goes back to, I mean, like your original question, and it has a lot to do with, like as my colleagues here on this panel have said, it's about opportunity. As John mentioned, he observed even some students at the university level who had not had prior experiences having, you know, some shifts adjusting to that type of thinking. So what happens with probably generally the population that our audience member asked about is you have to go back and think about the school setting. So what's happening in our schools where we have a lot of our economically disadvantaged students or our students where we have our schools more marginalized populations? Are they having equal access to those programs?

That would allow them to partake in the STEM activities. What about the teachers who are in those settings? Are those teachers having access to high quality, standards aligned, but ongoing professional learning experiences so that they understand the importance that STEM is not just a field for certain genders, it's something for everyone because we are evidence of people being taught to teach one way, but we don't see it prevalent even now, 30 plus years after that. So what typically happens, if a teacher participates in a sit and get, or there's a one-on opportunity, but there's no support to help you to sustain that, people go back to what they know or what they experience themselves. So you have a lot of folks, they were taught. That this is something that's only for males, or this is a field that's for males.

So they don't intentionally project that on their students, but they unintentionally do that because that is something that they were taught and so they believe that and they don't get enough experiences

with professional learning, with the materials, with resources to see the difference and maybe no one comes to those schools. To provide them with that type of outreach and support. And this is where it's really important that we have opportunities for all schools, especially when we start thinking about our public schools, to have access to the resources to provide those type of professional learning experiences for all adults who are working with students. And so, As Jennifer said, sometimes other things get in the way or take priority in some of those settings. But there have been times when there were funding sources, such as the math science partnerships, when we had Eisenhower funds, those were things that were national, federally funded projects. And it wasn't prioritized by this zip code, that zip code.

Every public school had access to this. And so we were building a cadre of teachers who were having access to this type of training, to that professional development that was really stoked in the research and the practices. And what was good about it is it was ongoing. I had the benefit of being a part of three of those type of projects at three different times in my career. So there were three different types of funding sources, but they all had the same premise. But what it did is not only gave ongoing support, it helped you to build a learning community, so you had someone else to reflect with, to talk to, to support you as you were learning something new as the teacher, but you were also focusing on what students were doing and the student work. So you were looking at what your students were doing as you learned yourself. And so as a result, we saw an increase in achievement. In all of our schools because of that influence from those programs. So it helps the students, but it also helps the teachers, and it helps with retention of keeping teachers in those classrooms because they're getting the support for the things that they need.

HANSEN: Great. Thank you, Latrenda. Jennifer, I think you wanted to also hop in on this on this issue.

CHILDRESS SELF: Yeah, I love, Latrinda, that you were thinking about the teacher aspect of how to address this issue, which is so critical. When I heard the question, I immediately thought about Gloria Ladson Billings and thinking about kind of the expectations that we have of students. So we've traditionally just talked about STEM subjects in a really restrictive way with We'll do one right answer,

one right way to get to the answer. Um, but when, when we look at the research, um, and especially at the research on how black girls learn, uh, it, we start eliciting and valuing multiple perspectives and ways to look at problems when we, when we look the classroom. Um, so this, the research says we should really center instruction, like John was saying, on the contexts and the problems, uh that students see are relevant to their lives.

Like we've all been talking about. And to their communities. And the research also talks about giving students more agency in their learning, such as by choosing, for example, their own problem to solve as a summative assessment, choosing to give their answers verbally versus in writing, if writing isn't a learning goal. So there are many different ways that we've now established in the research that we could start addressing this.

HANSEN: Thanks, Jennifer. I want to focus on the technology piece here and how disruptive artificial intelligence. John has talked about instructing a virtual reality class. And so maybe, John, you can kick us off a little bit. But I guess let's first focus on what are opportunities. What are the opportunities that AI, VR are presenting here for STEM instruction and how might this be helpful. We'll get to the drawbacks in a second. So let's go to that opportunity.

PECORE: All right. Opportunities with AI. You know, like I said, with the pre-service teachers I have, you know, they have to create a project-based learning mini unit, I call it. So typically a unit's maybe like three or four weeks or so. But these mini units, I ask them to just keep it down to one or two weeks since they don't have that much time in a one semester course. So We went into an AI program. And typed in some things to help design these lesson plans, a 5e lesson plan. And those my math students and my science students and we should have an article coming out here in the Journal of College Teaching pretty soon. But what we found were the lesson plans that creative were more connected to students, more real world, more creative.

So it really helped. You know, I think there's some hesitation in that maybe the AI is going to generate the whole lesson plan and stuff, but that's not the case. They've got to know what to put in there, what words to type in, how to structure things. So that takes a lot on their part as well. So I saw a lot of

improvement in that category. I was at a conference, I can't remember where it was, but there was a group from Germany which were doing a study on grading laboratory assignments. And so they had a control and experimental group where the control group were the teachers that graded the laboratory assignments, and then they had AI, an experimental group, grade the laboratory assignment, and the AI did a phenomenal job on grading these lab assignments. Of course, it was programmed with, you know, the criterion thing. I think there were only like one or two categories that they have to go back and tweak and figure out.

But in most cases, the when they really had an independent person kind of look at it, they determined that the AI actually did a better job than the teachers in some aspects and more consistency in the in the grading of the assignments. So I think there's a lot to help teachers maybe. I've always said that technology doesn't replace teaching but helps to improve teaching. There's like a support for our teachers to make their work a little easier. If we can have the teachers do more observing in the classroom and do more formative assessing of their students in the classrooms, and technology can hopefully help to provide that time in the classroom for the teacher to ask questions and observe and formatively assess where there and SARS so they can help scaffold them appropriately. That's what I see as the value and focus of technology.

HANSEN: Yeah, thanks, John. Jennifer, Latrenda, what do you see as some of the benefits here? Anything beyond what John has mentioned here? Lesson planning, some grading, which are all important too.

KNIGHTEN: But one of the things I think we have to always remember is as long as I can remember people say, oh, computers are going to take the place of a teacher. So human interaction, human involvement is very important. We are humans. So first we have get over that fear. So I think it's all about teachers and students becoming AI literate, understanding what the tools can do and what they can't do. And so how do we embrace it? So John mentioned a lot of the things that we as educators can do to use those as tools to support our work. But think about for some students how it can help to remove possibly a barrier.

So at a certain point, students may have a very complex problem because we're talking about real world, real life problems that students are solving. So if they can use, for example, a technology tool to take away the computational part because they need this data to input, to actually analyze it, to problem solve, to use critical thinking to think about it. And we do have some students who do have identified learning disabilities that make that something that is a challenge for them. For example, if I could use that to remove that barrier, but then it helps me to get to the problem solving aspect, so that I'm actually looking at a real world problem. It's not what happens in the real world. Aren't there people who possibly have some struggles with some of those resources, but they use it as a tool, but they do very complex activities to help us in the world to perform a job.

So let's embrace what it can do and what it cannot do and find ways to integrate those tools. So that we learn to use them as resources. And our students learn to be connoisseurs of technology because they don't just take an answer or a response as the end all be all. I'm going to have enough knowledge to question the answer or the result that I get so that I can problem solve to see if it's reasonable. So I think it's about embracing them as tools and resources. And just the other thing I would say, You know, John has mentioned a lot about VR. Just think about the opportunities that we bring to students or to ourselves that we can't bring by having those virtual reality opportunities, things for students to explore, observe something that you can't physically take them on a trip to, you know, the African Sahara or whatever to look at these things. So how can we use these as resources to enhance the learning environment? So I think it's all about being connoisseurs, teachers and students, and embracing them as tools and resources and using them purposefully and intentionally to support learning.

HANSEN: Yeah, thank you, Latrenda. I'm looking at our time. We want to pivot to audience Q&A in just a moment. But I do want to maybe bring up the possibility of some of these threats that AI or virtual reality may pose as well. Maybe, Jennifer, let's go to you first. So we agree that thinking like a scientist is important, being able to do some calculations is important. Are we worried that AI might be doing some of these things and maybe we're not actually training math and scientists for the future now with AI. Is that something we need to be worrying about? Jennifer?

CHILDRESS SELF: Yeah it's a good question. There are a lot, I totally agree with Latrenda that it's all about the critical consumers of these tools. The tools can be helpful just like any tools but it's how you use them. And so we do need to be watching out along the way how do we train our students to distinguish between what's helpful, what's less helpful, what's factual and reasonable and what's not. Um, so if we prepare our students to be critical thinkers in that way, and I'm not saying that we're doing a great job yet of doing that, but we can continue our implementation of all of those things, then we're maybe doing all we can to guard against some of the downsides.

HANSEN: Okay, great. And sort of a follow-on point to Jennifer, should we be rewriting some of these STEM standards in response to these technologies?

CHILDRESS SELF: Yeah, there are two aspects, I think, to STEM standards that are at play here. So many states have computer science standards that include the content and skills that students need to understand and program AI or other technologies. But then separately, I think all of the STEM areas and all of disciplines, all of education has a part to play in that of preparing the critical thinkers. So embedding teaching, embedding the thinking and reasoning skills that students need in the future for whatever they do encountering all these challenges. And those are already in at least the science standards. It's just a matter of implementing them.

HANSEN: Yeah, thank you. Thank you. We're transitioning to audience questions here. And so I'm gonna, I have a few different pieces that I'm going to try to categorize together, but we're on the topic of AI. So I'm just going to bring this one in. Timothy Wojahn from the National Science Foundation asks, given the potential threats of AI dominating innovation based on codified knowledge, would promotion of STEAM, that is STEM integrated with the arts, with its emphasis on non-rational modes of thought, can that be a better hedge against skill obsolescence? So can the integration of arts into STEM help to hedge against AI dominating us perhaps? Any thoughts here? Maybe let's go to John, what do you think?

PECORE: Thanks. That's a tough question. Gosh, it makes me think of Thomas Asmus as one of my colleagues at University of Florida, who is all about this integrating of arts and steam and AI and stuff.

And he would be much better at answering that question than myself. You know, I was just kind of thinking maybe with Jennifer was talking about where, you know, earlier she said about you know, the one right answer kind of thing. And we're trying to get students to think more critically, but also when assessing student understanding, we're trying to assess where they are in their level of understanding, right? And so early when AI was implemented, I thought, well, this would be an opportunity for that. You know, to maybe encourage that critical thinking, encourage more on identifying where they're at in their levels of understanding as opposed to just whether the answer is correct or not.

As AI has improved, so has its ability to critically think and help students provide answers in that direction. So yeah, but I think maybe in terms of, you know, creating projects and things that really get and Jennifer also mentioned about instead of we've written answers, maybe verbal answers and things. So maybe other forms of assessment are going to needed to circumvent. You know, to try to really get at what students understand and how they're learning. I don't think I answered the question though.

HANSEN: Well, you did a good job. Here we go. So on that same point of asking about STEAM, we have another questioner who writes in Daniel Dermasich, I don't know if I have the pronunciation right, of Rochester Coalition for Public Education asks, there have been past attempts to incorporate arts into STEM, making it STEAM. Okay. And has that effort continued and why or why not? Maybe Jennifer, maybe you want to quickly take this.

CHILDRESS SELF: Yeah well it's uh it's difficult actually to answer because I've seen so many definitions of STEM and so many definition of STEAM so sometimes it's art, sometimes it is agriculture, sometimes it’s architecture, and then when you try to incorporate the A discipline it could mean just adding on to one of the four STEM areas or it could be teaching some of the STEM areas through the context of that A discipline or creating fully integrated courses that teach everything together. But I haven't seen a consolidated movement in the country to support one particular interpretation. So I think to get anything at scale, we'd have to come together on a vision of what we actually want to happen.

HANSEN: Thanks for that. Oh yeah, yeah, John, go ahead if you want to pile on.

PECORE: Well, I agree, not at the level, but maybe at the district level there are. We have a district here, Santa Rosa County, which had about five, six years ago, implemented a steam initiative where they started in elementary schools and implementing steam kits. You know, there's a company that they bought these kits for, and they started it through their curriculum in the, in the city. So I would encourage it, check out Santa Rosa county in Florida and see about their steam initiative.

HANSEN: Yeah, thanks. So this question around interdisciplinary pieces, one of the emphases that also often are talked about whenever we talk about STEM instruction is that ideally, STEM instruction is described as an interdisciplinary approach. It is something where you could draw on math, you could on science, technology, et cetera. But often times in K-12 settings. We approach it with a single lens. This is our biology class, and we're just talking about the science here. An audience question is on this exact point. Nabila Bashir asks, how ready are schools to actually apply a multidisciplinary approach in teaching through STEAM strategies and tools? They're using STEAM here, but we can even think of STEM. How important is it to be interdisciplinary here? Maybe that can go to Latrenda.

KNIGHTEN: You know, this is related to the previous question as well. Um, life doesn't happen in isolation. So when I get up in the morning, I don't say from nine to nine 30, I'm only thinking about math related things. Or my brain is only doing things related to math or only doing things for ELA or, you know, for science or social studies. So. Some schools, I will say, are more ready than others because I know I'm in Baton Rouge, Louisiana. I know we have some of our schools in my previous school district that do a better job than others. Some elementary, some secondary of looking at that interdisciplinary approach.

One of the things that's helpful is that's how we help support relevance for students because having things that are all disjointed and that aren't connected. It doesn't encourage sense-making. And I know that's a big idea in science standards and math standards for sense- making. And I've even seen it mentioned in literacy standards. So I think some are more ready than others and there are

pockets of examples. You know, as Jennifer mentioned, we don't have a singular model that everyone has adopted but I think there are lots of pockets of the examples. And as we attend professional conferences from our content organizations, you see more examples of this to show teachers, how do you do something? When you start talking about project-based learning, you're talking about looking at a topic or a lens through multiple content areas and just thinking about how things are connected.

So you're fostering sense making, you're sponsoring coherence and really helping students. To see relevance and to see things as they happen and occur in the real world. I think students are ready for this and in interviewing students, and particularly I'm talking about our adolescents, they are articulating that this is the type of thing they want to see. This is what makes sense to them. So I'm seeing some shifts because the students are telling us what they want and what they need. And so there are some folks who are listening because the students are definitely more capable of speaking out for themselves than I felt as a kid in school. But so they're asking for what they want and what they need. There are resources to support them in these endeavors. And I think it takes us out of those silos. You know, students should not see. Things that are in silos or whatever, you know, that things don't connect and they don't cross the content area barriers or whatever. I think we have to think outside of those silos.

HANSEN: Okay, great. Thanks, Latrenda. We have a couple minutes left. I'm going to try to see if we can get a couple more audience questions here. Scott Traylor of 360Kid writes, research consistently shows that spatial skills are among the strongest predictors of STEM success. Yet K-12 curricula largely ignore spatial reasoning development, given that these skills are highly teachable and could significantly impact student retention in STEM. Why do you think spatial understanding remains absent? Maybe this is a great question for Jennifer. Let's try to do it as a lightning response, see if we can get to more, another question or two.

CHILDRESS SELF: Yeah, so I'll be very quick and then I would love to turn it to Latrinda. Because in my understanding most states math standards, there's at least implicit connections to spatial reasoning, but it's true that it's rarely explicit. But we've seen in the last 15 years of state standards work that if people enough people in the field decide something's important for students. We could

work together to make changes to standards that would then affect the classroom experiences in millions of students.

HANSEN: Thanks, Jennifer. Latrenda, do you want to jump in and add one more thought there?

KNIGHTEN: As Jennifer said, there are specific standards that are addressed to this as early as pre-K, if people have pre-k standards. Probably Scott is referring to, is there has been a priority place on so-called major content standards. And so what happens is when you identify something as major, someone assumes the others are minor, and so they give more attention to that. But we forget that spatial skills are one of those innate things that very young kids do. Toddlers, you know, innately. Perform those type of tasks and those are the types of wonderful toys that you purchase for young students. So we need to bring those things to the forefront more as we talk about that because that's where students will find success in geometry in middle and high school because they've had those experiences I think. So I think it's not making something major something minor, how do you integrate it into the other content areas? Of the other strands of math so that they can see the connections, I think.

HANSEN: Great. Thank you, Latrenda. And it looks like we are running out of time for any more audience Q&A, but let's just do one more last time around the horn for everyone. Just final thoughts or a message here quickly. Let's start with you first, John.

PECORE: Yeah, I think, you know, as technology improves and, you know, I was thinking about that last one with spatial reasoning. So we had construction management class and the students, some of this many of the students have a hard time with the spatial reasoning of reading a schematic. So, we took them into VR, and we did a honey, I shrunk the kids and we shrunk them down and put them in the HVAC system in the VR that we created, so they you know visualize or, you know, in VR, what they were seeing on the schematic. So I think we need to think about ways that we can help our students to, you know, improve in those deficit areas, like spatial reasoning and reasoning and things, more experiences that we give our students, whether it's by VR or whether it is project-based learning type activities and things and get them to. You know, enjoy and learn our STEM subjects.

HANSEN: Great, thanks, John. Jennifer, why don't you chime in here? Any final words that you wanna leave with us?

CHILDRESS SELF: Well, it's a really hard time in education right now, so I just wanna leave us all with a little kernel of hope that we've talked about a lot of things that we would love to see in education, and I think that these things are possible. So if education, if district leaders, if state leaders have a vision that they want to make happen, it can happen if we just change the systems. And put it into place such that it'll stay, stick around for the long-term, the sustainable.

HANSEN: Thank you, Jennifer, and last word to Latrenda.

KNIGHTEN: I agree with my co-panelists. We are in some interesting times, but we do have a lot of resources available. We just have to be a little bit more creative about how we utilize those resources. So I would say to anyone who is thinking about making systemic change, like within a school or even with an entire school system, think about the resources you have around you in your community. So how can you leverage those partnerships and those experiences to help bring that experience to your students, then the community at large, and capitalize on what we know we need to provide for students? You'll be surprised at how many people are willing to volunteer their time, their skill, their expertise to support the schools and their community. So we have to think a little bit outside the box and how do we capitalize on the resources we have available to us when we have limited funding and probably limited people supplies. There's a community here that's willing to support. Let's reach out to them.

HANSEN: Great, thank you, Latrenda. And so I will wrap it up by saying, we just wanna thank everyone in the audience for participating, for those who've written in and for listening in. And thank you to the panelists and also thank you to the Brookings team for the event support. This includes Chris Watson, Krista Lanning, Tara Moulson, Nicola Cervino, Gabby Harris and Ed Berkey. And thanks everyone and you have a great afternoon.