DAY 1: Tuesday, September 13, 2022

Katie O'Shea (she/her): Good morning from Ohio (also!). I am part of a team exploring development of data science lessons for K-8.

> **Kristin Hunter-Thomson, Dataspire**: @Katie I look forward to hearing more about your efforts. I provide data-related professional development for inservice and preservice teachers grades 3-12…and am always looking for lessons to share out with teachers I work with. kristin@dataspire.org
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> **Katie O'Shea (she/her)**: @Kristen, @Deidre - We are early stages in exploration, but would love to stay connected. Using this conference to better understand current state of offerings and needs. (koshea@mos.org)
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> **Chad Dorsey**: @Katie – You're in our neighborhood (Concord Consortium) – would love to connect and chat about this with you — I'll reach out!
>
> **Deidre Richardson - NJ**: @Kristin, @Katie, that would be fantastic! deidre.richardson@doe.nj.gov

Kristin Hunter-Thomson, Dataspire: @Rob Yes, for laying the foundation and building up from Pre-K/Kindergarten!

Jo Boaler: Thank you for pointing out the problems in math education Josh, we cannot go in the same direction with DS

Jean Moon: How does data science help to integrate, bring together STEM subjects, helping to break down content silos - interested in hearing thoughts/experiences on this question.

> **Rachel Connolly**: @Jean (hi!) I think that "data stories" are opening up more interdisciplinary narratives and novel insights
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> **Leigh Peake**: @Jean Moon -- agreed. The transdisciplinary nature of data science is one of the most promising things we see in the work in K-12.
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> **Susan Meabh Kelly**: @Jean Moon and @Leigh Peake Promise of including more than one discipline in learning also brings its own set of challenges, as often noted in integrated STEM literature.
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> **Leigh Peake**: Agreed Susan but we have moments of transcending the obstacles -- let's talk about doing that more and better!

Maya J Ayazi: I think the speakers are missing the point. The fact is that statistics is -- for whatever reason -- has become the way established way to talk about the world -- even in our court systems where an understanding of probability is important to be a jurist.

Christopher Orban: In Ohio, data science is listed as a math course and math teachers (even without CS credentials) are allowed to teach it. Most other states list data science as a CS course. Which is it from a fundamental perspective? Are there practical reasons to list it as one or the other?

> **Christopher Orban**: (I'm talking about high school)

Alfred Spector: To answer the question from Christopher Orban, I think pragmatically we will see data science taught by experts coming from the different backgrounds, and the courses will differ based on this

Jacob Sagrans: Great to see both NSTA and NCTM on this panel. Is anyone from CSTA here?

Amy Stephens: Not on this specific panel

Dave R: Unfortunately, teachers are not teaching math in math classes! For example, students are taught to solve quadratic equations with the famous formula, but are not shown where the formula comes from. This is not math, it's magic (like what Harry Potter does at Hogwarts). This is how most people, including many math teachers, seem to think about math. Rather than trying to retrain thousands of math teachers we need to be developing computerized instruction to teach students directly.

Jennifer Noll: @ Dave, I'm curious about your thoughts on computerized instruction as the solution. For K-12? Why do you think computerized instruction is the best solution and what might be lost in such an approach?

Jo Boaler: Interesting idea from @Dave but we need solutions that help teachers learn, not go around them.

Dave R: @jennifer, @jo: I don't think we can retrain teachers but we can develop computer games which teach math very effectively in a one-on-one experience for the students. Computer games are self-motivating and students proceed at their own rate, and games and other such software can be developed once and disseminated widely.

Joe Polman (he/him): Thanks for the beautiful characterization of an integrated approach to data science from Trish Shelton wrapping up that round — students with agency addressing pressing societal phenomena with data as a key componentm drawing from multiple disciplines - yes!

Leigh Peake: +1 Joe AND we can't realize that vision without tackling the numerous practical problems teachers and informal educators run into when giving youth more agency around the problems they want to pursue using data. Lots of "last mile" problems ...

Hosun Kang: @Joe Polman: I agree--students with agency addressing societal phenomena that matter to them with data

Jo Boaler: it would be hard to make things worse for students than they are now, in terms of equitable pathways - this movement is so important.

Leigh Peake: +1 Jo

Adam Tashman: The idea of a data science pipeline is so valuable. From developing a question to communicating with stakeholders, and all the statistics / CS in the middle. Students become knowers and doers, not just memorizers.

Kathy Berry: @Adam...we have students working with linear regression as early as 8th grade. We use technology tools in HS to fit functional models to data sets. None of these students are using calculus. Students at college could venture into the calculus side of house.

Kathy Berry: It might be very helpful if there were a group statement from a colleges of all status levels (Ivy league to community colleges) that calculus is no longer the end-all, be-all for mathematics for students; that while some students need some calculus for their college coursework/careers, nearly every person needs data literacy, and this can come through Data Science courses.

> **Adam Tashman**: @Kathy one question when we develop data science curriculum: when should students learn how to fit a regression model? this process involves calculus.
> **Christopher Orban**: Kathy, it is important to understand that professional data scientists need calculus. The "backpropagation" step in neural networks is incomprehensible without calculus.
> **Susan Meabh Kelly**: @Adam Focus on liner regression and what already exists in state math standards (Common Core)
> **Adam Tashman**: @Kathy agreed on your point, and I think that is the right time.
> **Adam Tashman**: thx @Susan agreed.
> **Kathy Berry**: @Christopher...yes, at the college level, certainly calculus is part of the toolbox for those studying data science beyond an intro course. I would suggest that there is a lot of data literacy and use of data (and critique of data and its use) that can be done especially 6-12 without calculus. And, it intrigues and hooks some students into digging deeper at the college level (and gives some motivation to taking calculus).
> **Jeanette Hickl**: @kathy what technologies are you using in HS?
> **Aanand Vasudevan**: @kathy - agree 100%
> **Kathy Berry**: @Jeanette...wish I had more to say here; in Michigan we are just venturing into formal Data Science courses. We have some initial adoption of Code.org resources. Speaking only to my awareness in my county, we still have very limited use of even Excel and Google Sheets in mathematics courses (mathematics teachers haven't received training in them).
> **Katrina Schwenke**: @Jeanette, I will be teaching Data Science this year in VA. The technologies we are utilizing are google sheets/excel, CODAP, and python.
> **Jenifer Hooten**: Teaching a Data Science course for the first time in New Mexico using the same thing, Katrina - Google suite, CODAP, python, etc. I'm utilizing the curriculum from YouCubed currently.
> **Jeanette Hickl**: @kathy @katrina Anaconda is used often in the university setting to teach python and R for data science. Our mission is to continue to provide access tools that empower data literacy. We know that our tool, although free, isn't ideal for K-12 environments. We adding learning tools to our platform as a resource in hopes that we can help support your curriculum while creating a free, cloud resource soon.
> **Jeanette Hickl**: jhickl@anaconda @kathy @katrina
> **Katrina Schwenke**: @Jeanette The biggest hoop to jump through has been the accessibility of these programs, not just whether they are free, but the so many of them don't make it through our schools filters or cannot be used on a Chromebook. We are on try number three for finding a program that allows us to run Python without jeopardizing the privacy issues of teaching at a high school (Google Colab and Kaggle have both been rejected, we are trying replit now).
> **Jeanette Hickl**: @Katrina Right. We have heard that from others. Could we stay in touch? I would like to see how we can understand the school filters and technology challenges you are facing. jhickl@anaconda.com
> **Katrina Schwenke**: @Jeanette Of course, kschwenke@harrisonburg.k12.va.us

Hosun Kang: As someone who involves in preservice teacher education, a core challenge is addressing this 'ever growing list' of what preservice teachers should learn within limited time. I'd love to hear others' thoughts about this.

> **Kristin Hunter-Thomson, Dataspire**: @Hosun this is such a great point about how to integrate this in without it forever being additive for our preservice (and inservice teachers). We are working with @Mel Zrada and @Mike Jabot on this for preservice faculty at the moment. Want to connect? kristin@dataspire.org
> **Hosun Kang**: @Kristin, thanks!

Jo Boaler: AP Stats is just a valid course as AP Calculus. We should not be comparing everything to calculus.

Jennifer Hicks: @Jo Boaler (huge fan BTW) agreed and our biggest issue is teacher instructional practice. I'm doing a year of lesson study with my teachers and reading "The Teaching Gap".

Aanand Vasudevan: Data Science can be viewed a a trans-disciplinary platform to integrate - science, math/stats and cs curricula to create integrated learning experiences which are relevant, applicable and honestly more interesting for students. The beauty is that this can be done on a variety of technological platforms

Hosun Kang: As someone who involves in preservice teacher education, a core challenge is dealing with this 'ever-growing list' of what preservice teachers should learn within the limited time. I'd love to hear others' thoughts about this.

Richard Duschl: There is serious agenda for data science to span the natural sciences and social sciences and doing so through the important lenses of modeling and systems thinking.

> **Kristin Hunter-Thomson, Dataspire**: @Richard and @Trish agreed!
> **Missy Holzer**: @Rick - agreed!!
> **Gregory MacDougall Virginia**: @Rick - YES!

Christopher Orban: The reality is that kids need as much math as they can get.

Engida Gebre: If we say there is mass application of data in every aspect of society, our teaching of data science/data literacy benefits from being relevant for everyday life of students and citizens—beyond producing competent data scientists or professionals

> **Emma Klugman**: @Engida, that's a great point about how data science skills aren't just important for careers or for future data scientists, but for critical thinking and citizenry
> **Kristin Hunter-Thomson, Dataspire**: @Engida and @Emma agreed. I think this is also why the trans/interdisciplinary topic the panelists are talking about is coordinated across and within the courses being taught in K-12 schools.

Christopher Orban: Who is the NSTA rep on the panel? I didn't catch her name

> **Amy Stephens**: Tricia Shelton, NSTA

Kim Kastens: I don't see anything in the agenda or in the comments so far about map-based data, geography education, or geographic information science. If you look at the data that appears in newspapers, and thus is important to every citizen, a lot of it is spatial data displayed on maps.

> **Susan Meabh Kelly**: @Kim Kastens Perhaps this initiative is worth revisiting: https://nap.nationalacademies.org/catalog/11019/learning-to-think-spatially
> **Richard Duschl**: @Kim - yes earth system sciences with probes guided by citizen science
> **Leigh Peake**: You know I agree, Kim! One of the challenges of engaging youth genuinely with climate change is tools to track change across both space & time. Neither tools nor pedagogy are well refined for that yet.
> Missy Holzer: +1 Kim - agreed. Data visualizations as you suggest provide pathways for more and more students to engage in data that is important to them!
> **Kim Kastens**: Thank you @Susan Kelly. I was part of the Learning to Think Spatially NAS consensus study that you cite at https://nap.nationalacademies.org/catalog/11019/learning-to-think-spatially and it is definitely full of important insights that should be revisited. That report may have been before its time.
> **Susan Meabh Kelly**: @Kim I know ! Glad to see you are here.

Leigh Peake: Is it helpful in K-12 to distinguish between building skill in producing/applying data analysis vs deducing meaning from and critiquing other people's data products? Does that help us move data science across/among disciplines? (Genuine question!)

Jean Moon: In spending time with a nearby science laboratory, it is amazing to hear them talking about the importance of learning how to have conversations with data , to the point of reflecting what we find in NGSS - explanation, argumentation and modeling.

> **Leigh Peake**: +1 Jean. When youth write for our middle school journal of science writing, Findings from the Field, teachers report they turn back into work with the data again & again because it intersects with the thinking their doing about building an argument in writing.
> **Jean Moon**: @Leigh Peake Great to hear!! Helping students not be afraid of data is so important. Thx for sharing.

Steve Pierson (American Statistical Association): To see what several two-year colleges are offering in terms of data science/analytics, see the Q&A's in the American Statistical Association monthly publication last month: https://magazine.amstat.org/blog/2022/08/01/new-two-year-programs/

Rachel Saidi (She/Her): At my community college, 75% of our data science students are working professionals possessing undergrad/graduate degrees. I find that our feeder high school students have never heard about data science as a discipline. Adults are far more aware of the need for data acumen/literacy

> **Aine David**: Very true Rachel same case here in Uganda

Helen Quinn: Learning from and with all types of data need attention, the mathematics and statistics elements are only part of what is needed. Asking questions about the sources and limitations of how the data was collected, who was included/excluded … all of this is critical at k-12.

Leigh Peake: +1 Helen
Jenifer Hooten: +1 Helen
Esme Tovar: +1 Helen
Traci Higgins: +1 helen
Engida Gebre: Thanks @Helen
Engida Gebre: @Helen, the use and abuse of data to empower /limit communities and individuals as well...
Kathy Berry: +1 Helen; our Michigan Disciplinary Literacy Essentials (mathematics section) addresses critiquing data as communicated in various forms; now for the field to include those in teaching and learning...
Kristin Hunter-Thomson, Dataspire: +1 Helen "all of this is critical at K-12"

Dave R: When I was doing graduate classes on statistics at Berkeley there were two different tracks: mathematical and applied. The math classes derived statistical methods while the applied classes were basically cookbook with no fundamental understanding. I've worked with social science faculty who have no idea how or why statistical methods work, which is why there is so much demand for professional statisticians. Just as you can't do calculus without trig, you can't really understand statistical methods without calculus.

Maya J Ayazi: The Census Bureau have developed many new tools and webinars to allow the population to interact with the data.
Kathy Berry: @Maya - agree, US Census Bureau is a wealth of real data at a variety of levels (down to school district, zip code, etc.). Read data 6-12 students could see relevance in. Data can be downloaded.

Candyce Curry: Where can we access the guidelines he mentioned?
Chad Dorsey: @Candyce: https://www.amstat.org/asa/files/pdfs/GAISE/GAISEIIPreK-12_Full.pdf

David Han: an excellent guideline: Pre-K-12 Guidelines for Assessment and Instruction in Statistics Education (https://www.amstat.org/asa/files/pdfs/GAISE/GAISEIIPreK-12_Full.pdf)

Engida Gebre: Thanks Victor for the DS and DL conceptualization…

Aine David: Thanks David Han and Candyce

Christine Franklin: Also from ASA a book to support GAISE II https://www.amstat.org/docs/default-source/amstat-documents/SDSTeacherBook-highres.pdf

David Han: The debate over statistics and ML/AI will never get settled.

Kim Kastens: I find the distinction just made between “data literacy" and “data science" to be valuable. Data literacy is what every American needs, and I hope the workshop will go deeper into what this is about.
Engida Gebre: +1@Kim

Kim Kastens: And yes, I agree with Alfred, that the education needs both: data literacy for all and data science for some
Kristin Hunter-Thomson, Dataspire: @Kim +1+1
Leana Nordstrom: @Kim +1!
Missy Holzer: @Kim - +1
David Han: @Kim +1

Deborah Boisvert; CSforMA, Inc.: EDC and some schools in MA are working on an NSF project for creating an Innovation Pathway for Data Careers (IPDC) that includes creating data-rich Civics projects in Social Studies.

Rachel Connolly: Regarding career pathways, I thought it was interesting that the NSF Science and Engineering Indicators in 2022 added new "STEM-related" fields in their Labor Force (mainly due to the increase of data literacy needed in these fields (trades, repair, production)

Richard Duschl: Capacities with quantitative representations are critically important with Data Literacy - developing, reading, comprehending . Tufte 'The display of quantitative information'.

Amy Hammett: Hello, Everyone. To give some input into Andy's question, data science, ML/AI is so INTERDISCIPLINARY that the greatest barrier I have encountered is how teachers can implement it into disciplines. At the higher education level, where I am now, we are recreating our pathways to be interdisciplinary.

Kristin Hunter-Thomson, Dataspire: @Amy I want to second bringing up the barrier. I have had success working with teachers across multiple disciplines within the same room at the same time to help them think about what they do in their different disciplines in support of one another, rather than in parallel. Curious to hear what others have found to help promote the cross discipline (and cross grade band) collaborations.

Christopher Orban: This is why the focus needs to be on concepts, not tools
Christopher Orban: Is how I would answer that question.

Jenifer Hooten: Agree, @Christopher. It would be helpful to have better standards for Data Science, as opposed to trying to force, so to speak, the Common Core standards to match up.
Kathy Berry: @Christopher, agreed; the programming languages I learned 30 years ago are no longer used, but the logic and disposition to continually learn new tech tools remains.

Jo Boaler: Rob Gould and I worked on setting out data science big ideas K-12: https://www.youcubed.org/data-big-ideas/

Jenifer Hooten: Thank you, Dr. Boaler!
Aine David: Thank you Dr Bo

Richard Duschl: What then are the 'fundamentals' and contexts that facilitate?

Joan Harper-Neely: The NASA eClips team worked with NASA GLOBE to develop a video design challenge. The challenge asks student teams to address science misconceptions by making claims and

collecting data. This interdisciplinary performance assessment is a great way to engage students while modeling the importance and uses of data.
https://nasaeclips.arc.nasa.gov/resources/sdchallenge/5

Aine David: I would love to get more insights on data science in K12. Please In case you can help with some resources email me at davidaine544@gmail.com

> **Leana Nordstrom**: Hi @aine. EDC's Oceans of Data Institute (ODI) has a collection of resources for K-12, that might be helpful! http://oceansofdata.org/our-work/teacher-resources
> **Aine David**: Thanks @Leana

Leana Nordstrom: On that ODI resource list is Data Science 4 Everyone, which also offers a collection of resources: https://www.datascience4everyone.org/resources

Kathy Berry: Data sets - see also DASL - Data and Story Library: https://dasl.datadescription.com/

Missy Holzer: Artist Nathalie Miebach incorporates data into her artforms. Visit her inspiring work Here: https://www.nathaliemiebach.com/

Anne Leftwich: Link to website: https://projects.ctintegration.org/

Kim Kastens: Interesting point that there is resistance to integrating data science into science courses. I think that one possible reason is that science educators and curriculum developers have worked really hard to develop learning activities in which students collect and then interpret data. But a lot of data science activity begin with professionally collected large data sets that the students were not involved in collecting, and that is seen as problematic.

> **marcia barton**: +1 Kim. Relevancy to students' lives surfaces.
> Kevin Waterman: (Hi, Kim!) We've heard students note the same thing: some say working with data wasn't "science"; instead they miss the "hands-on" activities. (As you note, these middle school students report that experimenting and generating their own data is science, but analyzing and interpreting existing data doesn't feel like science.)
> **Kristin Hunter-Thomson, Dataspire**: @Kim This is a great point and reality of integrating data into science classrooms, and I think a critical aspect of supporting our teachers integrate both learner-generated and professionally-collected data into our classrooms. And what are the overlaps among these kinds of data and skills students need to work with each of them.
> **Susan Meabh Kelly**: @Kim "first-hand" data vs "second hand" data. Also interesting when you consider how UC system did not value Earth science as a lab-based course for some time, despite many Earth science teachers leveraging archived and real time scientific data (e.g. NOAA, NASA, EPA, USGS).
> **Anita Palmer**: +10 @KimKastens

Kim Kastens: I and some EDC colleagues wrote about how to help students transition from small student collected data sets to large professionally-collected data sets at: Kastens, K. A., Krumhansl, R., & Baker, I. (2015). Thinking Big: Transitioning your students from working with small student-collected data sets towards "big data". The Science Teacher, 82(5), 25-31 (I put this into the resource page). The list server

for New York State Earth Science teachers has had discussions of whether data-using activities count as “labs" for the purpose of accumulating the required lab minutes required before sitting the NY state Earth Science Regents exam.

> **Kristin Hunter-Thomson, Dataspire**: @Kim Yes, such a great resource...highly encourage all to read.
> **Anita Palmer**: @Kim very excited to dig into your article. Thank you!
> **Susan Meabh Kelly**: Complementing @Kim Kasten's suggested article, here I describe transitions between small and large data sets in an under-resourced school: https://www.nsta.org/science-teacher/science-teacher-mayjune-2021/digging-data
> **Kim Kastens**: @Susan Meabh Kelly: Digging for Data looks like a great article. Thanks for sharing.

Richard Duschl: Working large data sets - either student generated or professionally generated - a necessary step is interrogating the data to derive patterns, outliers, and other steps for asking questons of the data.

Rachel Connolly: centering the classroom context in our tool and curricular design is critical to the success of resources

John McNamara-BANR, WSAS: the comment on quantitative reasoning and thinking..right on. stop 'scaring' people with you 'need math' you 'need data science' and just show them how and why we do what we do..

John McNamara-BANR, WSAS: The WSU learning goals: Graduates will solve quantitative problems from a wide variety of authentic contexts and everyday life situations. Don't stress 'math' , use quantitative reasoning. I spent my career on biomathematical models and never took calculus..

Candyce Curry: That is an amazing observation and idea!

Jenifer Hooten: So true! We're not really teaching math. :)

Candyce Curry: Making all content in high school relevant to real-world situations is a limitation that we are experiencing.

> **John McNamara-BANR, WSAS**: @CC...do you mean you are limited in finding real-world situations? or that using the approach (of using real-world situations) is limited in use?
> **Candyce Curry**: @john the approach
> **John McNamara-BANR, WSAS**: @CC thanks...keep up the integration as best you can! it works...there are examples at NGSS and NSTA websites.
> **Candyce Curry**: @John sure! I am a curriculum person but the issue lies in the expectation that teachers teach toward testing and not toward problem-solving
> **John McNamara-BANR, WSAS**: @CC yes the testing issue remains. In our state (WA) we dropped all the tests except those still required by NCLB. But our tests (as I helped with them) are deep in problem solving so 'most' teachers teach that way or are getting there. We will

always have some kind of assessment, so we need to adapt the assessment along with the curriculum.

Candyce Curry: @John I agree assessments are essential, adaptation in the curriculum is a must!

Lisa Balazs (she/her): I appreciate the phrase "tyranny of testing"

Tracy Ostrom: If we are forming partnerships within schools/districts, we need to provide relief of standardize tests and content mandates for all.

deanna kuhn: I am surprised by the absence thus far of a perspective of a developmental psychologist, who are known for studying learning progressions. As one, I am no doubt slanted this way, but feel free to write me if you'd like to read one I've written on developing data literacy K-12.

Barbara Hopkins: We were ahead of our time in June, 2020

Kim Kastens: I like the distinction between Reading the World with Data and Writing the World with Data.

Kristin Hunter-Thomson, Dataspire: +1 Kim

Vasudevan, Veena: I appreciate that question but wonder if we can also ask the question 'what does quantitative reasoning look like across different disciplinary contexts'/ through different cultural lenses?
Vasudevan, Veena: And I often wonder this... do we need to have scalable solutions? Can we instead focus on cultivating criticality?

Dave R: "Your focus determines your reality" (Qui Gon Jinn). Your goals will determine your approach to research, your analysis and your results. This is called 'confirmation bias' and it's widespread in the literature. How do we recognize and avoid this?

Adam: @Dave- check out Bergstrom and West's book- linked on the resources page.

Dave R: @Adam: Thanks. Why hasn't anyone mentioned BS today?

Kristin Hunter-Thomson, Dataspire: +1 for good assessments…and that are growth mindset oriented

Christine Franklin: For examples of good statistical assessment look at LOCUS website https://locus.statisticseducation.org

Jo Boaler: Thanks Christine

David Han: the direction of data science education should be diverse, encouraging both conceptual understanding and applications.
David Han: CS way is largely practice oriented and backfires when the model becomes biased.

Kathy Berry: Making room...we could revisit the full-year HS geometry course present in most high schools - is a full year really needed; and, there are already some projects teaching the upper CCSS algebra/stats content via Data Science courses.

David Han: the direction of data science education should be diverse, encouraging both conceptual understanding and applications.
CS way is largely practice oriented and backfires when the model becomes biased.

Barbara Hopkins: These discussions are long overdue! Thank you everyone!

Tyler Kloefkorn, American Mathematical Society: I wonder if one potential desired outcome of K-12 data science education is: preparing students for studying STEM in higher education? And if so, can the panelists comment on how to change perceptions of "calculus is the only way to STEM degrees". Note: there have been a number of articles on this topic, from the Dana Center, Just Equations, and others.

Jo Boaler: High school - especially math - should be completely reconsidered - so much could be streamlined and DS could take some of the place of algebra and geometry

> **Vasudevan, Veena**: @Jo I always wonder about designing semester long problems where students can dig into larger conceptual areas by staying with a set of topics that they continue to develop/explore
> **Vasudevan, Veena**: and look at them through disciplinary lenses
> **Jo Boaler**: I love that @Veena
> **Chris Lippi**: Agreed @Jo, I think a lot of high school math from alg1-Calc could be taught within a data science framework of sorts
> **Helen Quinn**: +1 Jo, a total redesign of high school could allow much more effective and efficient learning across multiple interconnected disciplines
> **Engida Gebre**: +1 @Veena , @Jo

Kristin Hunter-Thomson, Dataspire: @Seth's comment re: when and where skills are taught across our different disciplines not often being coordinated in scope, sequence, and approaches resonates a lot with my classroom experience and in the many schools, districts across the US we now work with. This feels like a big thing to figure out and consider when promoting the integration of data into and across disciplines (which I strongly support).

Vasudevan, Veena: This is where I come back to the notion of data literacies (versus science) becuase it allows for us to think about literacies as transdisciplinary

Vasudevan, Veena: and the ways we can allow studnets to pose inquiries (like the one Jo you posted) and really explore them

S Bearman: Interdisciplinary collaboration is increasingly necessary to understand the domains into which students will apply their talents. Also, many of us at the college level are including more and more data science (and data. models, and statistics) in lower division computer science courses.

Vasudevan, Veena: with support... and time to look at data sets, ask new questions, collect their own data... and on

Vasudevan, Veena: I also think that teachers outside of the traditional STEM fields feel disconnected from these discussions even though they are deeply implicated in all disciplines

Luke Henke: Breaking those systemic barriers that prevent collaboration is paramount. That's where my mind drifts as I consider these beautiful shifts in education.

Vasudevan, Veena: I think if we can imagine a problem, like the ones Jo posted, e.g. 'who grew up with childhood trauma?' Then we can put that in conversation... what is the problem space? what are kids asking? what data can help us know something about that?

Vasudevan, Veena: How do data sets get constructed?

Vasudevan, Veena: who collected/communicated the data... and what more needs to be known?

Kathy Berry: RE: HS course/pathway redesign, a wall we run into after a lot of student-centered, creative thinking is: "But colleges require Algebra 1, Algebra 2, Geomety, PreCalc...and they want to see AP courses". Colleges could do MS/HS mathematics a great service to explicitly allow for multiple pathways through pre-college content.

Vasudevan, Veena: I did my dissertation at a high school that mapped the requirements onto courses... so colleges could see official classes, while the students engaged in more cross-disciplinary learning spaces

Vasudevan, Veena: so they could be more dynamic

Larry Buck: Citizen Science! Great notion. Requires Data Accumen

Kate Welsh (she/her/hers): Also known as Community Science to avoid the use of the word "citizen"

Jo Boaler: from Harvard's admissions statement: Applicants to Harvard should excel in a challenging high school math sequence corresponding to their educational interests and aspirations. Rigorous and relevant data science, computer science, statistics, mathematical modeling, calculus, and other advanced math classes are given equal consideration in the application process. Specifically, calculus is neither a requirement nor a preference for admission to Harvard.

> **Vasudevan, Veena**: @Jo that's really interesting. Although (and unfortunately) this still is so exclusive… all the more reason to find ways for schools in nondominant communities to have more options and access to courses in these disciplines.

Larry Buck: pros and cons for using the word "citizen"; agency is active vs part of passive mass

Helen Quinn: What colleges want changes over times too, perception of these things from teachers and parents can be outdated, part of the work is to ensure the relevant changes are happening and part of it is to support changing perceptions of these things.

Richard Duschl: Data Inquiry - The 5 Ds for Planning and Carrying Out Investigations. Duschl and Bybee International Journal of STEM Education (2014) 1:12 DOI 10.1186/s40594-014-0012-6

Jo Boaler: I have to go back to our conference now but it was a pleasure chatting with you all. All of our data science resources can be accessed here: https://www.youcubed.org/ Just choose “data science"

Kim Kastens: About exclusion issues with the use of time-honored term “Citizen Science," Environmental Protection Agency uses the term "Participatory Science.” See https://www.epa.gov/participatory-science/quality-assurance-handbook-and-toolkit-participatory-science-projects

Traci Higgins: Just addressing data science within mathematics for a moment...My daughter's high school experience was Alg2 (experienced as a review of Alg1)->Geometry-->Mathematical Modeling--> Calculus (she went to a magnet school). I wonder why we don't have a mathematical modeling class in the usual mathematics trajectory. Why do we insist on distinct silos within the mathematics? What if in K-12 we focused on developing a broad understanding of mathematics that was grounded in computational thinking, statistics/data science, quantitative reasoning as opposed to distinct branches of mathematics. They have college to get into the weeds of all that.

Christa E. (she/her) MALC: That was super cool! Danke sehr!

Vasudevan, Veena: Love the idea of bodying the data

David Han: CS prefers python while stat prefers R
David Han: engineers also prefer minitab and matlab

Lisa Ogiemwonyi: I have also found Python to be commonly used with engineering experts who are doing projects with big data

S Bearman: Some of us have given up on R for quick things like more intuitive and quick graphical programming environments like KNIME -- and the Python environment when necessary (Python and R are available through visual environments, too)

David Han: we need a programming-language-independent tool for teaching K-12 about the concept of data science.

Dave R: In general in every subject area students should be able to explain why they are studying this subject and how it can fit into their lives. The answer “because it’s on the final” is not acceptable. If the student can’t explain this, should they really be studying this subject?
Students should be able to parse through large sets of data and be able to organize it in a meaningful way (e.g., graph, data visual, description). Then, they should be able to present the data in a way that answers a clear statistical question (or data question) so not only they can answer it but others could create the answer by studying the data visual. Most of the time, the person who created the data visual

isn't there to explain it. It should be self-explanatory in a way others can gain knowledge about the question.
Dave R: In a country where journalists don't know the difference between percentage and percentage points students should learn to question authoritative claims and determine on their own whether what they're hearing makes sense. "Trust but verify."

> **Vasudevan, Veena**: @DaveR + ... i see that also as critical data literacies
> **Vasudevan, Veena**: And @DaveR, to your point earlier reL: journalism, to me your example speaks to critical data literacies; being able to critique/deconstruct data

Arturo: I am using Python for teaching math and statistics, also some electronics.

Vasudevan, Veena: and coming back to Jo's point from earlier re: reading the word and world and being able to speak back to institutional data by deconstructing/critiquing it

Lisa Ogiemwonyi: CODAP has been really helpful with students and educators to analyze data, and particularly with large data sets!

Kristin Hunter-Thomson, Dataspire: @Chad's discussion of the aspects of the tool (regardless of what interactive data visualization tool is used) I find is really important to make apparent for teachers to get the "why" of a dataviz tool rather than Sheets/Excel (spreadsheet program like @Victor mentioned) as it connects to the habits of mind for our students to gain.

> **Vasudevan, Veena**: @kristin +
> **Kristin Hunter-Thomson, Dataspire**: +1 Andee re: tool progression area of research
> **Vasudevan, Veena**: Yes @Kristin and @Andee

Harshil Parikh: for those looking at CODAP, you should also checkout Tuva's data, graphing, and statistical tools
Harshil Parikh: you can find them at tuvalabs.com

Jacob Sagrans: We just want to acknowledge the work of Cliff Konold, the original creator of TinkerPlots (didn't hear his name mentioned).

Harshil Parikh: and yes - Cliff Konold and Craig Miller's work and contributions from their work at UMass Amherst should be acknowledged as well

Vasudevan, Veena: Randy's points makes me think about the importance of co-design, of being in classroom spaces before we go about designing in a vacuum

Vasudevan, Veena: And even when we talk to teahcers, there is something so valuable in being in the spaces; observing the culture of the classroom unfold

Vasudevan, Veena: And to Randy's other point,re: professional learning, teachers need time to play with these tools in PD

Kathy Berry: Fathom is/was the follow-up to Tinkerplots for HS use. Both tools were real eye-openers for ES/MS/HS teachers during PL sessions - they'd done basic stats number crunching before but never thought of data "moving" into the various graph forms depending on what you did with it.

Vasudevan, Veena: slides aren't nearly as valuable as them solving their way through problems that we would pose to students

Vasudevan, Veena: we need equal amounts of play in teacher education / professional learning

Harshil Parikh: Accessibility should also be able ensuring students with learning disabilities can also use data and graphing tools

Vasudevan, Veena: I just realized I was posting to hosts only:) ... two quick things: (@Kristin, appreciating your posts) ... and re: Randys' points: 1. We should engage in meaningful co-design 2. Teachers need to be able to play during professional learning... with the same tools we expect htem to use with students.

> **Kristin Hunter-Thomson, Dataspire**: @Veena Yes, we have found it absolutely critical for teachers to play themselves with data, in the tools, doing the things they want their students to do in PL workshops…and then time to discuss what it could like in implementation.

Vasudevan, Veena: Yes! I've seen the same in science education. When teachers are able to engage in practices you get to know them, they get to think through those problems; and then you are modeling the pedagogies we hope to imagine in their classrooms

Kristin Hunter-Thomson, Dataspire: +1 on Victor's comment re: tools, and the easily updated aspect especially

Lisa Ogiemwonyi: Yes! I also agree. A data source for teachers would be great. I spent many hours scouring the web looking for data sets related to basic Materials Science and Engineering.

> **Harshil Parikh**: Lisa - tuvalabs.com/content/ might a place to check out

Susan Meabh Kelly: I have observed secondary science teachers sharing authentic data sets for specific learning goals. It would be valuable to include them in future conversations and co-design efforts.

> **Vasudevan, Veena**: @Susan agreed!

Harshil Parikh: we have a library of 500+ ready-to-use datasets for teachers

Jennifer Noll: And TinkerPlots too! With the sampler as a visual tool - with possible expansion into pseudocode

Michael Huberty: I agree that I wish CODAP could do all TinkerPlots and Fathom could do.

Kim Kastens: I think there is a place for curated--but authentic— data sets that contain clear-cut exemplars of important phenomena in various STEM disciplines. As @Lisa said, it is possible to sink vast

amounts of time in professionally-collected data sets looking for suitable data snippets in which students can unearth a relationship that you want them to see. Science experts in those disciplinary domains can often recall where such exemplars may be found.

David Han: I think this is very dangerous to showcase how to use the tools without understanding how that works.

Lisa Ogiemwonyi: STEM Case Studies with Data Science would also be really helpful.

David Han: this has created all kinds of algorithmic bias problems we are facing today

Lisa Ogiemwonyi: Sometimes it is hard to get case studies because certain experts in industry do not have permission to share their data sets, even if just portions of data sets.

> **Jeanette Hickl**: @Lisa if Anaconda can help with data sets and free educational tools, please let me know. jhickl@anaconda.com

David Han: these tools are very CS oriented without teaching any concepts of probability and statistics which are the fundamental principles behind.

David Han: everyone is excited to apply data and crunch numbers but without understanding the statistical concept behind, this is a weapon of mass destruction, creating all kinds of misinformation. i hope we all realize this

Harshil Parikh: for people who are interested in our work to make the Tuva tools truly accessible for students with various learning disabilities
Harshil Parikh: please checkout out this link: https://support.tuvalabs.com/hc/en-us/categories/360004269434-Accessibility-of-Tuva-Tools

David Han: many people do not even understand what standard deviation means. the concept of probability should be taught early on for better practice of data science.

David Han: data literate people do not need to practice data science but data scientists must be data literate.

Kim Kastens: I want to support the current speaker pointing out something important: emphasizing the importance of being able to interpret the data visualizations you see in the newspapers about issues of the day, such a masking or climate change.

> **David Han**: @kim +1 also "critical" consumption of information presented to us

Laura Akesson, AEF: In my classroom, I use data from GapMinder. Free, searchable data in the spirit of Hans Rosling's Factfulness.

Julie Back: The Virginia Space Grant Consortium and West Virginia Space Grant Consortium recently partnered on a project to integrate authentic NASA data sets into the computer science curricula of

Code.org. Curating the data sets (which focused on two natural phenomena: air quality and urban heat islands) seemed to be the most challenging aspect of the project for teachers who developed the lessons and resources. I'm hearing there is a need for similar data sets- good to know, as we intend to expand on this work in the near future. As was suggested here, curating the data sets so that important trends can be spotted by learners, and so that they are reasonable in size and scope, is quite a challenge.

Kathy Berry: Future research: how to make decisions and transitions between tools geared toward teaching-and-learning data literacy and data science (e.g., Tinkerplots, CODAP, and the like) vs. tools people outside of schools (K-12) use to deal with data/data science (e.g., Excel, SPSS, r, Python...). Are there viable ways to have common underlying habits of mind and processes (similar to the Standards for Mathematical Practice) that just may look different from one tool to another.

DAY 2: Wednesday, September 14, 2022

Kim Kastens: That was a great summary of themes from yesterday. I heard two other themes: (1) That there are two different student groups who need different learning goals: every person in the 21st century needs a broad set of data literacy capacities, and a small-ish subset of people need a set of data science capacity that will prepare them for data-intensive professions.
Kim Kastens: Themes continued: I also heard yesterday: (2) We need to attend to students' capacity to extract meaning from data (this was touched on in "data stories", but I think there is a broader theme here.) I think this idea includes translating from data into reality, for two kinds of meaning: causality (why?) and consequences (so what?) And it also includes translating in the opposite direction, from reality into data (if this were true, what kind of data would show that and what would the data look like?)

brian conrad: What does "statewide program" mean? A teacher training program, or separate courses in each state/country, or …?

Kim Kastens: Why is Earth/Space/Environmental Science missing from the slide with Science pathways? These sciences are very rich in data!

Kathy Renfrew: even fewer elementary school educators and this applies to young children too

Missy Holzer: Paul is an amazing educator!!

Veena: Loved that framing… epistemic authority+ what counts as data +
Who gets to produce and define what data is

Kim Kastens: Paul Strode is emphasizing that there are a handful of statistical concepts that students need to understand about data. But there is a whole additional universe of things that need to be understood about how data is collected. In my own field of oceanography, even a simple-sounding data type like the temperature or depth of the ocean in a given place, is not straightforward to measure. There is a set of students who may be much more attracted to problems of how to design and build a data-collection device but not so interested in the math of how to analyze data. This is a plea for K-12 data education to include a strand that has to do with designing, building, and deploying instrumentation to collect new data.

Neil Desnoyers:Speaking of "data science shouldn't be taught at 8:00 AM", for several years I taught an intro engineering stat course at the college level that met one afternoon a week for 4 hours - on Saturdays! To make matters worse it was a fall term course - so students had to give up football games to come and learn stat. I know this is a K12 discussion, but I thought I would mention it. FYI - I've also had many positive experiences teaching stat and analytics.

Dave R: If an educator doesn't realize she's doing data science that's a good sign; data science has been effectively incorporated in her view of the world. This should be the goal.

> **Veena**: @Dave R- I might push back to say- when they realize what they are doing could/ is data science - teachers have language they can use and that also nurtures their own confidence/ identities in relation to these topics

Veena: Saw this with early childhood educators and science, It was eye opening for them to see their everyday classroom practice through lens of science teaching and learning. It inspired more intentional science

Dave R: "Good heavens! For more than forty years I have been speaking prose without knowing it." - Moliere Le Bourgeois Gentilhomme 1670

Traci Higgins: Paul Strode, there is an interesting discussion of height and wingspan in Epstein's The Sports Gene—pro basketball players are especially unusual compared to the population at large for longer wingspan relative to height.

Vasudevan, Veena: It sounds to me like the space to setup a problem; even define the problem space; think about inquiries in relation to larger ideolgoical/social/cultural contexts... makes it feel like 'data science'... that's a helpful perspective

Kristin Hunter-Thomson, Dataspire: +1+1+1 To Paul's call for teacher support and training

Dave R: The best way to teach is through games, and the best way to learn is by teaching someone else. Teachers, and especially grading, tend to get in the way of this process. See "New experiments in self-teaching | Sugata Mitra": https://www.youtube.com/watch?v=dk60sYrU2RU

Kristin Hunter-Thomson, Dataspire: Building off of what Katie just brought up, I think our informal education centers are also important partners in providing opportunities for teaching and learning Data Science.

Kathy Renfrew: I wish more elementary educators were here because this is so important

Kristin Hunter-Thomson, Dataspire: Agreed with Suyen's comment on a need for authentic assessments AND a need for better articulation of what the PreK-12 progression of data skills are to build the assessments (and instructional materials and teaching practices) from. I think these are two important needs for research/funding.

Vasudevan, Veena: Agree with the commenter... the more we can bring these sensibilities into all disciplines is how it will make sense and feel relevant, Can imagine the same in social sciences/history

Kathy Renfrew: The commenter is right on.

Kristin Hunter-Thomson, Dataspire: Agree strongly that this should be PreK-12...and has a lot of power when we pull it into science and social studies education.

Vasudevan, Veena: thinking about the same problems through disciplinary lenses but also humanities and english education e.g. taking up inquiries students have, using data to write persuasive pieces, or whatever... compose their own data visualizations

Kristin Hunter-Thomson, Dataspire: I would LOVE to connect with anyone and everyone about supporting science and social studies teachers helping their students make sense of data. kristin@dataspire.org

> **Vasudevan, Veena**: @Kristin this transdisciplinary practice is something I'm really interested in! veenav@pitt.edu
> **Kathy Renfrew**: what about connecting to an elementary educator @kristin?
> **Kristin Hunter-Thomson, Dataspire**: @Kathy yes! I work with teachers mostly grades 3-12 & preservice. But more and more I am working with PreK-2 as well.
> **Michael Jabot**: @KRISTIN thank you!!!

Karen Givvin: We teach English class, but expect students to write in their other classes. Similarly, we should teach Data Science courses, but expect students to use/practice those skills in other classes.
Lin Chambers: +1 Karen!

Rae McEntyre: This question goes back to a previous comment in the chat--if teachers aren't aware that they're already incorporating data science into their lessons, then they'll see it as an "add on".

> **Vasudevan, Veena**: @Rae, yes agreed.
> Kathy Renfrew: @rae you are right on with that comment

Vasudevan, Veena: but re-framing is so hlepful versus ‘more things'

Vasudevan, Veena: A huge challenge I see in PA is the ways in which standardized tests really limit what teachers feel like they can do time-wise and so to say 'now you teach data science' spooks folks who are feeling the institutional weight vs ... what do you do? how do kids unfold problems? ‘oh cool! you're doing data science’..

Joan Harper-Neely: I love her initiative!

Vasudevan, Veena: What brilliant examples of what happens when young people are supported to engage in meaningful inquiries that are salient to who they are and the things that matter to them while still engaging in critical educational praxis.

Angela Hochstetter (MnDE): "maps are awesome"... great quote :)

Vasudevan, Veena: These presentations are also making me think about the thing that was lingering from yesterday - which is how are we supporting instructors, particularly those in data science, mathematics, statistics, to support discussion and discovery in topical areas in relation to data (like policing data) to support responsible conversations and learning experiences with young people?

Vasudevan, Veena: Social justice is easy to talk about ...much more difficult ot practice through pedagogies, through class discussion, through thoughtful attention to how students might experience these topics… but holding that in tension with not bothering with 'challenging topics' because it does young people a disservice

> **Amy Stephens**: @Veena -- I think that is the right question
>
> **Jenifer Hooten**: Yes, Veena - how do we support educators and schools to use data literacy and data science to promote social justice?

Vasudevan, Veena: And to Rahul's point, that's what we're doing here...
Vasudevan, Veena: I was a panelist at a quantitative methods conference...and the scholars there were explaining that there was never exploration of critical theory, theories of learning, etc. there was no space in higher ed... so it's no surpirse that continues

Lauren Levites: Thanks for these presentations, I am a CPS teacher currently watching with my AP Research students who are just beginning their research journey this year!

> **Vasudevan, Veena**: @Lauren, that's awesome!

Rachel Connolly: @lissa, I see that MIT Media Lab is a media partner on your site. Would love to know you contact so I can connect on my end (I am at the media lab)

> **Lissa Soep**: Hi Rachel! Yes we work with Hal Abelson's App Inventor team.

Neil Desnoyers:Teachers have been having difficult conversations with students, albeit not about quant issues, since, like, ...forever!

Richard Duschl: Learning goals in 3 part harmony - epistemic goals,

Kristin Hunter-Thomson, Dataspire: +1 Emmanuel "we need better, not more datasets" for students/teachers in K-12

Richard Duschl: social communication and critique goals, conceptual/cognitive goals. Learning to reason with modeling and systemic contexts.

Rachel Connolly: I am realizing that "data sets" and "data stories" are sometimes used interchangeably but need to be unpacks and distinct

Dave R: People seem to have disparaged spreadsheets, but they require users to do explicit operations rather than producing a 'magic' answer without showing any of the computations, which is often the case with 'data science' tools. It was mentioned earlier that doing the math steps increased student interest and understanding. Are data science tools preferable for education?

> **Susan Meabh Kelly**: @Dave I have found it valuable to include activities using spreadsheets before doing same in R

Kristin Hunter-Thomson, Dataspire: +1 @Leticia great point about large need to create opportunities for coordination and synergy across what we/teachers are already doing in their classrooms.

Kristin Hunter-Thomson, Dataspire: Both across disciplines and grade bands I think is important to think about.

Deborah Duran (NIMHD/NIH): durande@mail.nih.gov; I have real life opportunities for teachers to participate in real life research using the cloud, dat science, python etc. Please contact me if you are interested. Your students would be welcomed as well.

David Han: @Leticia a great point again. all those disciplines are defined in such a confusing manner although we all take them for granted.

Traci Higgins: Is calculus so import for college admissions because it is a predictor of wealth?

> **Dave R**: @Traci: I think calculus is so important for the same reason organic chemistry is important in pre-med programs - as a way to weed out students.
> **David Han**: @Dave: weed out, LOL. so true

David Han: AP stat curriculum should change to reflect the essence of data science.

Richard Duschl: How might the Data Science PD be coordinated, facilitated and integrated within informal Out-of -School venues? Takes a regional approach?

Pastor Edwards: The guide on the side lends better to this purpose, in my opinion.

Nicole Wong: +1 leticia!

Kristin Hunter-Thomson, Dataspire: +1+1 for learning community AND need for better collating/sharing out resources around professional learning

Richard Duschl: Network communities - one place to begin are the educational research organizations - AERA , NARST, NSTM, ASTC, etc. etc. and State Levels through NSTA regional conferences and partner organizations.
Richard Duschl: NCT

Pastor Edwards: Great point,

Richard Duschl: NCTM one more time

Shakiyya Bland, Ed.D. (she/her): What considerations does NASEM have for inviting K-12 state, district and building leaders to participate on a panel regarding the barriers/challenges and effective practices for implementing data science not just data literacy?

Rae McEntyre: +1 Dr. Bland! Such an important question.

Adam: Didn't catch this guy's name- he's great! Anyone catch his name?

Chad Dorsey: Steven Leinwand, from AIR
Kathy Berry: Steve tells it like it is - his books read just like this!

arlene.crum: Yes! Quick, accessible and useful books.

Lindsey Henderson: I'd love to move beyond courses for pre-service teachers to defining competencies. What are the knowledge, skills and dispositions that teachers need in order to teach DS content effectively? (and perhaps that comes as we develop DS standards in K-12 or at least in tandem…)

Traci Higgins: Yay ITV. I too grew up in a rural area.

Traci Higgins: Yes—credentialing process is torturous and does not work well for people wanting to shift fields in mid life. There are people with these skills that can't get into teaching positions.

Kristin Hunter-Thomson, Dataspire: Agreed @Andee

John McNamara-BANR, WSAS: whatever we do let us keep it simple. Let us (what she is just saying!) not what a DS pro needs, but what normal people need for quantitative reasoning and understanding. (the person at the mike just said this!)
Kristin Hunter-Thomson, Dataspire: @John +1 totally agreed

Jacob Sagrans: Maybe something like the 5 big picture ideas for AI could be a model for data science education https://ai4k12.org/resources/big-ideas-poster/
John McNamara-BANR, WSAS: @jacob S yes, that is a good approach

John McNamara-BANR, WSAS: end goal: people can interpret information in their daily lives without being a specialist in anything

Dave R: Swiss scientist Conrad Gessner worried about a hand-held information device causing "confusing and harmful" consequences. That was 1565. He was talking about books. (Nir Eyal)