The University of Texas at Austin
Charles A. Dana Center

Data Science Course Framework

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About the Dana Center

The Charles A. Dana Center develops and scales mathematics and science education innovations to support educators, administrators, and policymakers in creating seamless transitions throughout the K–16 system for all students, especially those who have historically been underserved. We focus in particular on strategies for improving student engagement, motivation, persistence, and achievement.

The Center was founded in 1991 at The University of Texas at Austin. Our staff members have expertise in leadership, literacy, research, program evaluation, mathematics and science education, policy and systemic reform, and services to high-need populations.

About K–12 Math Pathways

All students, whether they are college bound or choose to enter the workforce upon graduation, should be able to critically interpret and engage with data, understand data ethics, appreciate the power and limitations of mathematics and statistics, and use available technology to carry out investigations in authentic and meaningful contexts. However, many high schools continue to guide students to an algebra-heavy curriculum, even though the labor market increasingly requires skills such as statistics, data science, and quantitative reasoning. The goal of K–12 Math Pathways is to develop relevant, engaging, and intellectually challenging pathways for grades 11 and 12 that will enable students to achieve their postsecondary aspirations and lead informed and productive lives. Developed in collaboration with experts in K–12 and higher education, the framework contained in this document describes a course that would be appropriate for all students in support of this goal.

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Introduction

This data science course framework describes a data science course that combines mathematical, quantitative, and computational concepts and strategies to empower students to live skillfully and productively in our data-driven society. Course topics present students with a more realistic picture of how these concepts and strategies are used to address relevant, real-world problems. The framework includes course design principles and student learning outcomes, which, when applied together, can help students see how mathematics can provide the opportunity for success in further education and the workforce.

As students engage with course content and identify issues in their worlds to explore, they will approach solutions through a combination of mathematical, quantitative, and computational methods to problem solving, which will enable them to develop a deeper understanding of the benefits and challenges of each method. Students will use available tools and resources to tackle problems, using a data life cycle to make conclusions. Through a data science course modeled on this framework, students will have multiple opportunities to develop a level of algorithmic understanding and data literacy that is not a part of a traditional mathematics, statistics, or computer science course. In addition, they will be exposed to mathematical concepts that are essential for data literacy.

The modern practice of data science requires substantial use of software and applications. It is not reasonable to rely entirely on a graphing calculator or Excel, as this data science course focuses on learning from real data and authentic contexts, exploring bivariate and multivariate relationships, and communicating results through a variety of data visualizations. The design of this course should incorporate the use of appropriate statistics and computational software or other readily accessible applications.

Relevant and Representative Opportunities for Success

A holistic approach to ensuring that all students have access to and success in mathematics education requires establishing a curriculum that reflects the diversity of students' voices and perspectives while providing a multifaceted learning experience. Such a curriculum incorporates familiar concepts alongside new perspectives, ensuring representation, inclusivity, and relevance. Students should be encouraged to critically analyze mathematical tools and models in context, promoting an understanding of the limitations and ethical considerations of technological advancements.

This critical lens extends to evaluating datasets that nurture a discerning approach to statistical and/or computational analyses and interpretation, challenging assumptions, and recognizing biases. Pedagogical approaches intended to reach all students foster belonging, center sense making, and address power dynamics. They require creating an inclusive learning environment where students feel empowered to engage deeply with material, connect concepts and data to their lived experiences, question established norms, and leverage their different cultural backgrounds as valuable resources.

Ongoing support and resources via accessible and relevant professional learning are necessary, with an emphasis on awareness among educators and supporting programs that cultivate the development and support of teachers from all backgrounds. Likewise, assessment designs should prioritize student agency and multiple demonstrations of reasoning, accommodating diverse learning styles and contexts. Assessment data should also prompt reflection from school administrators and instructors to address disparities in student outcomes. Finally, technological tools used in mathematics education must prioritize accessibility, affordability, and inclusivity.

Course Design Principles

Curriculum designers, districts, and schools will find this document useful when developing or evaluating data science course materials. The design principles that follow describe how curricular materials should be structured and implemented to support a coherent and engaging experience, with an intentional balance of conceptual understanding and procedural fluency.

Curricular materials should emphasize the value and importance of actively engaging students in constructing knowledge. Students—especially those who feel disconnected from mathematics and disaffected by the learning process—should be given the opportunity to develop their mathematical, quantitative, and computational abilities, while engaging in meaningful, authentic work.

Ensuring that instruction serves the needs of diverse student populations cannot be an afterthought in the curriculum design process—it must be centered and examined throughout development. To that end, implications for equity are spotlighted for each principle so that designers can use these principles to create curricular materials and professional learning. Teachers are invited to investigate and implement other pedagogical strategies that are supported by research and to customize the curricular materials to best serve their unique student populations and contexts.

Through this course, we hope that students develop greater confidence in their ability to demonstrate their understanding of mathematical, quantitative, and computational abilities; think critically about how content is contextualized and delivered; and give feedback on how the course can be improved to better represent their identities, lived experiences, and aspirations. We hope that teachers come to class each day knowing that their time will be purposeful and impactful, and that they feel empowered by providing their students with a modern skillset and by equipping them to critique the collection and analysis of data. Ultimately, we aim for students to find joy and passion as they engage with content that matters to them and explore questions of interest, and for teachers to feel confident in their ability to deepen students' understanding of mathematics, statistics, and computational sciences.

We are aware that many students and teachers already engage in these behaviors so these principles can be viewed as reinforcing and supportive. The spirit of this framework recognizes that we are all learners and are growing in our understanding of mathematics, one another, and the world around us.

Note: The order of the design principles does not indicate the level of importance.

Equitable Pedagogy

Equitable pedagogy solicits the thinking of all students and provides for those contributions to occur in a variety of ways. Such participation is created by fostering a sense of belonging and strong relationships among students. Central to this environment is the idea of sense making, where students actively construct understanding rather than passively receive information. Educators should address issues of power and authority in the classroom, cultivating students' critical awareness of agency and positionality in the classroom and beyond.

Leveraging students' funds of knowledge (Rodriguez, 2013), which include their cultural backgrounds and experiences, enriches the learning process. Teaching must recognize and incorporate the cultural assets that students bring, even if they do not align with the dominant mathematical or technical language. Instruction should draw on the multidimensional nature of mathematics, integrating concepts, skills, reasoning, and communication. Using equity-focused frameworks, such as Universal Design for Learning (UDL) (Rogers-Shaw et al., 2018) and mathematics language routines (Zwiers et al., 2017), ensures that all students have access to and can benefit from the course material.

Designers will develop lesson activities, assessments, and teacher support materials that...

- Ensure that all students have access to an engaging, intellectually challenging curriculum.
- Support engagement in culturally relevant and sustaining pedagogical practices, drawing connections between mathematics content and lived experiences.
- Employ diverse active instructional methods (e.g., hands-on and technology-based activities, small group collaborative work, facilitated student discourse, and interactive lectures).
- Engage in authentic, real-world investigations through a data cycle, offering room for student choice (differentiated across individuals or groups).
- Promote active and social learning through facilitated interactions among peers, teachers, students, and community members, fostering opportunities for respectful discussions.
- Support engagement with culturally relevant role models of data scientists to understand the varied paths and applications within the field.
- Incorporate asset-based approaches that cultivate resilience while centering identity, interest, and agency through data.
- Use technology to explore and investigate to develop conceptual understanding.
- Allow flexibility to use additional, research-based pedagogical approaches.
- Incorporate strategies that position mistakes and failed strategies as opportunities to learn, and encourage self-monitoring and help-seeking behaviors.

Using curriculum that incorporates equitable pedagogy, teachers can...

- Use evidence-based, inclusive instructional methods that cater to the diverse needs of students with varying backgrounds, cultural experiences, and strengths, fostering an accessible and supportive learning environment
- Cultivate resilience, agency, and positive self-identity in all learners.

Equitable Pedagogy (cont.)

Using curriculum that incorporates equitable pedagogy, teachers can...

- Learn data science alongside students, fostering a shared journey of exploration without the expectation of being experts.
- Provide authentic experiences that empower students to make a positive difference in their communities through data science projects.
- Provide multiple means of engagement, representation, and expression. Regularly provide students opportunities for both individual and collaborative work, promoting a balanced approach to skill development and fostering teamwork.
- Monitor student progress and make needed accommodations, offering remediation and enrichment, and differentiating instruction when appropriate.
- Facilitate discussions on engaging and relevant topics, providing students with opportunities to develop communication skills specific to data science.
- Foster respectful peer discussions so students feel they belong and are welcomed to engage in the material.
- Make connections with students' previous knowledge, cultural backgrounds, experiences, and future postsecondary and career aspirations.
- Normalize help seeking by regularly reminding students about ways to seek support from both the teacher and peers, and create a supportive learning community.
- Equip students with problem-solving and troubleshooting strategies, offering opportunities to practice and refine these skills within the classroom context.

As a result of teacher behaviors that implement equitable pedagogy, students can...

- Develop a sense of belonging and self-empowerment in data science, cultivating a positive self-identity and recognizing the potential for personal agency in the field.
- Recognize that data science is an exploratory and iterative process, emphasizing and valuing continual learning and discovery rather than a focus on predetermined correct answers.
- Participate in hands-on experiences that reflect real-world data science practices, actively engaging with data for practical understanding and applying critical thinking to explain reasoning and justify conclusions.
- Engage collaboratively in debates, discussions, and activities, fostering a social learning environment that honors new perspectives and respects others' ideas and lived experiences.
- Examine societal implications and human impacts of data science by considering contextual nuances, power dynamics, and ethical considerations inherent in data science.
- Develop proficiency in modern software and applications, integrating iterative modeling techniques with both traditional and digital tools for industry-relevant data science skills.
- Cultivate a habit of critically evaluating technical approaches in data science tasks, emphasizing thoughtful analysis and decision making.
- Explore questions of personal interest using data science.
- Increase self-efficacy in data science and cultivate a willingness to persevere through challenges, fostering resilience and a positive attitude toward overcoming obstacles in the learning process.

Equitable Learning Environment

An equitable learning environment is inclusive of students from diverse cultural, economic, and linguistic communities. Administrators and school personnel should provide effective structures to support such a learning environment. Valuing and respecting students' identities—leveraging their multiple assets, including their lived experiences—foster a positive and empowering learning atmosphere. Encouraging discourse, agency, and positive perceptions of students as learners is vital for their success.

Designers will develop lesson activities, assessments, and teacher support materials that...

- Cultivate caring, respectful, and asset-based relationships with and among students.
- Create opportunities for independent and collaborative student work, while positioning the teacher as a facilitator and student discourse as the primary discourse in the classroom.
- Create safe spaces that normalize struggle such that students (and teachers) are able to make mistakes and learn from them through dialogue with one another.
- Present mathematics and statistics as necessary tools to model and solve problems that arise in the real world.
- Facilitate teacher reflexivity in how their power and authority influence the learning environment and impact students.
- Incorporate opportunities for students to develop and apply metacognitive strategies (planning, monitoring, evaluating, and reflecting on their learning), and to set and monitor goals.
- Consider the principles of Universal Design for Learning.
- Provide resources, such as videos in which professionals discuss and demonstrate how they use mathematics and statistics in their work.

Using curriculum that incorporates an equitable learning environment, teachers can...

- Empower students by helping them personally answer the question "When am I ever going to use this?" through practical applications of data science concepts.
- Establish a learning environment that provides multiple means of engagement, representation, action, and expression.
- Create a harmonious classroom learning culture in which students actively engage in the learning process by teaching, providing feedback to peers, and taking ownership of their individual learning journeys.
- Model thoughtfulness and respect when discussing social issues and other topics that may be personal or sensitive to students, creating a classroom culture that values diverse perspectives and experiences.

Equitable Learning Environment (cont.)

Using curriculum that incorporates an equitable learning environment, teachers can...

- Offer low-stakes opportunities for students to apply new concepts, providing a risk-free space for them to explore and apply their understanding.
- Provide students regular opportunities to work both individually and collaboratively with a variety of peers in the class, promoting a balanced approach to skill development and teamwork.
- Cultivate a supportive learning environment that normalizes collaboration with students, fostering a safe space for respectful and open discussion where making, reflecting on, and learning from mistakes are encouraged, creating an atmosphere for experimentation and growth.
- Place student thinking at the center of discussions, promoting inclusive and diverse perspectives.
- Instruct students of the value of a growth mindset, providing regular opportunities for reflection and improvement, and recognizing that students may be at different points on the spectrum between fixed and growth mindsets.
- Position students as self-sufficient learners while focusing on facilitation, monitoring thinking, and pushing students to apply higher level skills.

As a result of teacher behaviors that implement an equitable learning environment, students can...

- Feel empowered to apply acquired data science knowledge in their communities and daily lives, developing expertise as active contributors to data-driven knowledge and discovery.
- Develop a sense of belonging in critical science and technology fields (i.e., science, technology, engineering, mathematics), recognizing the capacity to produce knowledge and make new discoveries, and moving beyond the role of consumers to active contributors of data-enabled discoveries.
- Cultivate skills to effectively reflect on and improve learning, fostering a mindset of continuous improvement in the data science learning process.
- Engage in a supportive learning environment where comfort and encouragement prevail, trying new things, asking questions, and viewing mistakes as opportunities for growth.
- Approach data science with a growth mindset, acknowledging that proficiency can be acquired over time through continuous learning and adaptation.
- Learn to work collaboratively with peers, actively supporting them in their learning process and contributing to a cooperative and enriching classroom environment.
- Recognize and appreciate personal agency in the learning process and classroom environment, understanding that each student plays an impactful role in their education journeys.

Equitable Communication

Equitable communication is essential in high school mathematics, particularly data science courses. Activities should prioritize diverse modalities to accommodate various student needs, accessibility for students with disabilities, and multilingual learners. These activities should promote written, visual, and oral communication.

Integrating cultural knowledge and interdisciplinary connections fosters inclusivity, preparing students for future careers, while appropriate use of multiple communication modalities promotes clarity and literacy for various stakeholder groups.

Designers will develop lesson activities, assessments, and teacher support materials that...

- Allow students to demonstrate understanding, using various forms of communication (i.e., multiple modalities).
- Support accessibility in communication for students with disabilities and multilingual students.
- Provide opportunities for students to develop their ability to communicate about and with mathematics, statistics, and data in contextual situations, using written, visual, and oral formats.
- Provide opportunities for students to communicate the results of computational and statistical analyses and to justify data-based conclusions.
- Showcase students' project-based work (e.g., online portfolios).
- Provide guidance on supporting students in moving from self-created to standard terms and definitions.
- Foster communication, dialogue, and constructive feedback among students as a method for refining or revising views when evidence warrants.
- Provide students opportunities to value communication as a core decision-making factor in modeling, assessing tradeoffs between modeling sophistication and ease of understanding when deployed (e.g., "black box AI" versus "interpretable AI").

Using curriculum that incorporates equitable communication, teachers can...

- Scaffold data science learning concepts through group-based instruction, allowing students of varying comfort and fluency levels to contribute to projects in diverse ways, facilitating integrative learning experiences.
- Demonstrate precise communication in explanations and use accurate terminology when discussing data, analysis, and conclusions with students, ensuring clarity in teaching materials and fostering a shared understanding.
- Prepare students for potential terminology and notation used in specific career fields.
- Provide students feedback and opportunities for revision of writing assignments and presentations to enhance communication and presentation skills.

Equitable Communication (cont.)

Using curriculum that incorporates equitable communication, teachers can...

- Use scaffolding to help students learn how to structure data-driven arguments and written reports, promoting the development of effective communication skills in the context of data science.
- Facilitate discourse among students by positioning them as authors of ideas who explain and defend their approaches, using varied representations.
- Provide students opportunities to showcase their data science work, such as through a culminating final project, enabling them to share achievements made throughout the course. For team-based assignments, offer shorter individual tasks that students can share beyond the class, promoting individual contributions and broader dissemination of skills.

As a result of teacher behaviors that implement equitable communication, students can...

- Feel prepared for future careers by emphasizing the development of "whole human skills" that go beyond automated tools, focusing on interpreting, communicating, evaluating, and debating rapidly evolving data science models for industry or academia.
- Connect mathematical learning to language arts, visual arts, etc., making it a central and integrated component of students' learning journeys rather than an afterthought (e.g., how students communicate data, how they present data).
- Leverage their own cultural knowledge and practices from their communities, fostering inclusivity and cultural relevance in the learning process.
- Effectively communicate conclusions and data analysis decisions through both written and oral means, developing strong communication skills in the context of data science.
- Develop skills to effectively summarize conclusions from data analysis for diverse audiences, emphasizing the importance of clear communication in conveying insights derived from data.
- Describe their data analysis processes, including considerations of potential biases and implications of decisions made throughout the analysis, to promote transparency and critical reflection.
- Identify data visualizations, statistical and computational outputs that most effectively convey results when presenting data analysis orally or in writing, promoting visual and data literacy.
- Communicate about data using accurate terminology, while avoiding excessive reliance on jargon, to ensure clarity and accessibility.
- Develop skills to constructively evaluate data analysis results produced by peers and other practitioners, fostering a collaborative mindset within the learning community.
- Produce a portfolio of data analysis work, allowing them to showcase their skills, insights, and growth widely, providing a tangible representation of their learning journey.

Equity in Tools and Technology

Equity in tools and technology requires that all materials and tools are accessible to all students, comply with Americans with Disabilities Act (ADA) standards, and feature support for multilingual learners. Ideally, these technologies should be low cost or free to ensure accessibility.

Technologies should be compatible across multiple platforms and devices, and capable of handling large data sets efficiently. Addressing digital divides and generational differences in perceptions of emerging technology is essential in ensuring equitable access and engagement with the course content.

Designers will develop lesson activities, assessments, and with teacher support materials that...

- Use technology intentionally to enhance and support the student experience.
- Consider varying levels of students' technology literacy (i.e., prior exposure to technological tools); ensure accessibility while enabling students to have access to a range of tools and experiences; and give students agency in selecting the tool when appropriate.
- Use technology to wrangle, visualize, and explore data to develop conceptual understanding.
- Guide teachers to explicitly address challenges of intersectional digital divides (e.g., rural, family/generational perceptions on technology) as it pertains to artificial intelligence (AI), data, and tools.
- Focus on the affordances and constraints of various tools to select one appropriate for the task.
- Make use of computational and statistical software and applications for data analysis that are accessible to all students.
- Are open access, easy to use, accessible across platforms and devices, and robust to multiple contexts and data set sizes, with ongoing accessibility to students outside of class.
- Critique the responsible use of technology (e.g., the importance of reproducibility, addressing biases in AI).

Using curriculum that incorporates equity in tools and technology, teachers can...

- Seamlessly integrate new tools and technologies into time-tested lessons, drawing connections between prior tools (e.g., Excel) and new tools (e.g., Pandas) to bridge familiarity and promote a smooth transition for students.
- Support students with varying levels of access to technology at home, ensuring an equitable learning experience for all.
- Use professional statistical software (e.g., Python, R), even if it is not the primary technology in the classroom, providing a comprehensive and industry-relevant learning experience.
- Identify suitable software and applications for analyzing large datasets that are readily accessible to students, ensuring that the chosen tools align with the learning outcomes.
- Encourage students to explore statistical concepts through interactive tools and simulations rather than relying solely on formulas, fostering a dynamic and engaging learning environment.

Equity in Tools and Technology (cont.)

Using curriculum that incorporates equity in tools and technology, teachers can...

- Use scaffolding to help students develop a data analysis workflow that integrates with software tools for writing the results, facilitating a seamless and systematic approach to data analysis projects.
- Facilitate discussions that encourage students to think critically about the ethical considerations of the technology being used, incorporating broader discussions around AI and algorithmic bias, and fostering a mindful and responsible approach to data science.
- Develop guidelines for students' use of AI on assignments and other coursework, providing clarity and direction for responsible and ethical use within the data science learning context.

As a result of teacher behaviors that implement equity in tools and technology, students can...

- Develop technological fluency to prepare for emerging industry tools, ensuring adaptability and readiness for the dynamic field.
- Understand the value of automation as a time, money, and effort-saving technique compared to manual processes while also gaining exposure to manual methods for a deeper understanding and increased accessibility.
- Be exposed to practical and industry-relevant data science problem-solving strategies and techniques (e.g., rapid prototyping, whiteboarding, sketching, and manual planning) before implementing production-ready versions using software.
- Responsibly steward and critically analyze technology usage, addressing ethical considerations, such as data privacy and emerging AI ethical concerns, in data science practices and safeguarding against potential misuse in data analysis.
- Develop proficiency in using software and applications to visualize, wrangle, and analyze large data sets, gaining exposure to professional data analysis software for comprehensive skill development.
- Understand the importance of reproducibility and how technology facilitates a reproducible data analysis workflow, encouraging transparent and replicable practices.
- Learn to make decisions on the ethical use of new tools and technologies (e.g., AI) to support data analysis without hindering skills development, fostering a critical mindset towards ethical considerations in technology.

Equitable Contexts

Equitable contexts are those that resonate with and reflect students' cultural backgrounds, communities, fields of study, and personal interests. This approach not only makes learning more relevant and engaging, but it also introduces students to new and significant ideas, providing both reflective and expansive learning experiences (often referred to as "windows and mirrors" in the curriculum).

The curriculum should encourage students to collect data pertinent to their own lives, making their learning experience more personalized and meaningful. Moreover, the curriculum should offer students opportunities to critique the biases of functioning technologies (e.g., generative AI models such as ChatGPT) and quantitative methodologies (e.g., predictive algorithms) to foster their critical thinking skills. Applying a critical lens when evaluating and interpreting data sets is essential in helping students understand the broader implications and ethical considerations of mathematics for diverse communities.

Designers will develop lesson activities, assessments, and teacher support materials that engage students in meaningful work, using data and contexts that . . .

- Are scaffolded and accessible to learners from varied backgrounds, with local and national datasets of relevance to students.
- Are diverse, relevant, and authentic.
- Align with student interests.
- Reflect the experiences of student populations.
- Address topical and socio-political issues (e.g., disparate health outcomes).
- Position the work as preparation for a variety of pathways and careers.

Using curriculum that incorporates equitable contexts, teachers can...

- Ensure inclusivity and accessibility for diverse learners.
- Scaffold data science learning concepts through group-based instruction, allowing students of varying comfort and fluency levels to contribute to projects in multiple ways, fostering an integrative learning environment.
- Use culturally relevant data and contexts as both windows (offering new perspectives) and mirrors (reflecting students' experiences), fostering a connection between data science concepts and different cultural backgrounds, to create an inclusive and responsive learning environment.

Equitable Contexts (cont.)

Using curriculum that incorporates equitable contexts, teachers can...

- Highlight and periodically remind students how their work in the classroom is preparing them to work with data in a variety of careers, emphasizing the practical applications and career relevance of data science skills.
- Give students opportunities to think critically about decisions throughout the data analysis process, fostering analytical skills and promoting thoughtful decision making.
- Provide sufficient background information and scaffolding so each assignment is engaging and accessible to all students, irrespective of their previous personal experiences, ensuring equitable participation in the learning process.

As a result of teacher behaviors that implement equitable contexts, students can...

- Engage in relevant mathematical experiences.
- Connect mathematical knowledge to innate cultural knowledge and practices within their native communities, bridging the gap between academic concepts and lived experiences.
- Gain confidence in the value of their perspectives, recognizing their potential to address currently unsolved problems in data science, especially problems impacting their own communities.
- Develop experience leading data science projects from start to finish, emphasizing a comprehensive approach rather than simply "filling in the blanks," and mirroring the complexity and ambiguity often faced in industry settings.
- Develop an appreciation for how data science can be used to understand diverse perspectives and experiences, acknowledging the limitations of data in capturing the richness of human experiences.
- Appreciate the versatility of data science across disciplines and contexts, expanding awareness of its interdisciplinary nature.
- Learn to use data science as a tool to explore personal interests, reflecting lived experiences, and understand and communicate about locally relevant issues, fostering personalized and meaningful engagement.

Equitable Assessment

Equitable assessments fairly and accurately measure each student's mastery of course learning outcomes. Assessments should provide multiple ways for students to demonstrate their reasoning and understanding, where possible offering students choices that leverage their interests and strengths. Creating space for teachers to reflect on and address disparate student outcomes is crucial.

Designers will develop both formative and summative assessments that...

- Capture disaggregated student performance data in a way that facilitates examination for improving equitable student outcomes.
- Align with course learning outcomes, including knowledge, practices, skills, and dispositions.
- Employ a variety of assessment methods, including projects, portfolios, and presentations.
- Value conceptual understanding and student growth by prioritizing open-middle and open-ended items with diverse and relevant contexts.
- Allow for multiple ways to demonstrate understanding (e.g., how students analyze data) to ensure a comprehensive evaluation of students' skills and knowledge.
- Identify the intended informational purpose of each item, whether it measures conceptual understanding, procedural fluency, selecting appropriate strategy, etc.
- Are embedded with formative measures in appropriate places to yield actionable data that can lead to improved learning.
- Use diverse contexts and datasets.
- Are designed to give students the choice to engage in specific tasks/contexts.
- Provide opportunities for students to demonstrate their reasoning in multiple ways (i.e., different modalities).
- Encourage holistic ways of measuring learning (such as reporting "approximations of knowledge") rather than correctness, recognizing that there are multiple ways of knowing, each with pros and cons, that often vary across cultures.
- Allow for flexibility in assessment item contexts so teachers can use assessment items that are relevant to their students.
- Are adaptable to allow students to demonstrate understanding, using various forms of expression.

Using curriculum that incorporates equitable assessment, teachers can...

- Design authentic, problem-based assessments directly tied to real-world outcomes, incorporating evaluations by industry mentors and community members to ensure relevance and practical application.
- Build formative assessments that promote peer learning, rapid feedback, and learning through teaching, fostering a dynamic and collaborative learning environment.
- Regularly provide students with open-ended assessments that require synthesizing results of data analysis, encouraging critical thinking and comprehensive understanding.
- Develop rubrics that are flexible enough to align with each classroom's individual culture and needs, ensuring adaptability to diverse learning environments.
- Build alignments to related assessment tasks in other disciplines, classes, and standards (e.g., Common Core Math, Next Generation Science Standards [NGSS]), promoting interdisciplinary connections and reinforcing broader educational objectives.

Equitable Assessment (cont.)

Using curriculum that incorporates equitable assessment, teachers can...

- Grade to reflect student learning rather than completion of additional expectations that are not related to the class learning objectives, ensuring that assessments align with the core learning outcomes of the data science course.
- Provide a variety of formative and summative assessments, emphasizing ample low-stakes formative assessments before high-stakes assessments to support ongoing learning and skill development.
- Use assessment outcomes to improve teaching and student learning, employing a reflective approach to refine instructional strategies and enhance the learning experience.
- Design assessments that prepare students for future real-world learning contexts and careers by aligning assessments with practical applications, industry relevance, and using real-world data and applications, and reinforcing the connection between classroom assessments and real-world skills.
- Design open-ended assessments that encourage students to think creatively and critically about decisions throughout the data analysis process, fostering analytical and creative thinking skills.
- Design assessments that show students that there are multiple ways to approach data science tasks, recognizing and valuing diverse problem-solving approaches in the learning process.

As a result of teacher behaviors that implement equitable assessment, students can...

- Gain a greater sense of belonging in science, technology, engineering and mathematics fields, and recognize the diverse paths to success by understanding that success in the industry includes not only mathematically fluent data scientists but also those who excel in communication, civic engagement, and collaboration.
- Experience assessments as nonarbitrary and relevant to their personal lives and future interests, fostering a connection between academic assessments and real-world applications.
- Be better prepared for real-world contexts where there is often no single right answer, but rather a continuum of debate, reframing, iteration, and improvement in data science research, mirroring the dynamic nature of the field.
- Value evaluation as a key skill leveraged in many industry data science contexts, including benchmarking, auditing, and measurement. Apply this skill not only to their own models but also to models built by peers and companies, fostering a comprehensive understanding of evaluation in data science.
- Demonstrate conceptual understanding and the ability to implement data science methods to answer questions about real-world phenomena, showcasing practical applications of their learning.
- See assessments as part of the learning process and an opportunity to reflect on learning and to continue growing, emphasizing the ongoing nature of learning in data science.
- Approach assessments with a growth mindset, viewing them as a demonstration of understanding at that point in time rather than as a definitive marker of innate ability in data science, fostering resilience and continuous improvement.
- Begin to hone study skills that most effectively help them learn data science through periodic reflection on learning, cultivating effective learning habits and strategies.
- Have a portfolio of work by the end of the course that showcases their data science skills and growth, providing tangible evidence of their capabilities that can be shared widely and emphasizing the practical applications of their learning.

Equity in Professional Learning

Equity in professional learning refers both to creating an equitable and inclusive environment for teacher participants and to supporting teachers in developing an equity mindset. Educators need ample time and support for their professional learning, including regular feedback and reflection loops to evaluate and improve their practice.

Professional learning experiences should mirror those of students in mathematics classrooms, emphasizing sense making, belonging, and the development of a critical lens. Meeting teachers where they are in their professional journeys ensures that they receive the appropriate support and resources. An equity mindset is crucial for teachers to effectively address and understand the needs of their student populations.

Designers will develop comprehensive professional learning that...

- Is adaptable in terms of delivery methods.
- Is distributed over time.
- Fosters a community of learners.
- Facilitates opportunities to learn from data scientists across different fields.
- Involves active participation in a supportive environment.
- Builds an equity mindset in teachers via ongoing professional learning so that teachers recognize the need for mathematics pathways.
- Creates cultures and climates that support belonging, equity, and inclusion, and discusses content and pedagogy through an equity lens.
- Is asset-based.
- Models effective teaching practices.
- Introduces culturally responsive and sustaining pedagogical theory and strategies so that teachers can draw on the strengths and assets of their students.
- Leverages the expertise of district and school leaders, instructional coaches, and teachers.
- Meets the unique needs of districts, schools, and teachers.
- Supports teachers in reflecting on their classroom practices (e.g., cultural relevance, collaborative team exercises) and how they are viewed by and impact all students.
- Integrates technology.
- Includes cycles of classroom implementation where teachers apply their learning, reflect, and adjust.
- Emphasizes the importance of formative assessment and is time- and cost-effective.
- Provides regular opportunities for teachers to reflect on their learning and teaching practices.
- Addresses timely trends in popularized data science-related tools that are likely to impact students (e.g. generative AI).

Equity in Professional Learning (cont.)

Using curriculum that incorporates equity in professional learning, teachers can...

- Embrace learning data science alongside students without the need to be data science experts themselves, fostering a collaborative and dynamic learning environment.
- Understand that data science builds on connections to other classroom training, such as mathematics and statistics, as well as cultural and communal knowledge and practices passed down through centuries.
- Gain exposure to the data science cycle with opportunities to apply data science for professional benefit, ensuring teachers are well versed in the practical application of data science concepts.
- Use best practices when assigning student teams for group work, emphasizing productive collaboration and minimizing marginalization within groups.
- Regularly reflect on current classroom practices, specifically with a lens towards facilitating a supportive learning environment that is equitable and inclusive, promoting continuous improvement in teaching strategies.
- Learn from and exchange ideas with a community of data science instructors who teach a variety of student populations, fostering collaboration and sharing of best practices.
- Periodically update course content, activities, assessments, and data sets to stay current with innovations in data science while continuing to learn up-to-date methods, computing skills, and best practices to enhance instructional capabilities and responsiveness to evolving industry practices.
- Adopt evidence-based instructional practices and strategies that align with the diverse needs of the students.
- Safeguard students from harms of rapidly evolving technologies, such as generative AI, by leveraging up-to-date research in responsible, critical, and accountable data science and ethics.

As a result of teacher behaviors that implement equity in professional learning, students can...

- Learn from teachers who are confident in their subject matter and facilitation strategies.
- Access direct support from curriculum designers for issues that may arise beyond immediate teacher assistance, ensuring a comprehensive support system for addressing challenges in the early or new implementation of data science programs.
- Gain a sense of confidence and community by learning alongside their teachers, reducing the pressure to know the right answer ahead of time and fostering a supportive and collaborative learning environment.
- Benefit from and experience better learning outcomes from teachers' cycles of learning, classroom implementation, and reflection, ensuring a dynamic and continually improving learning experience.

Student Learning Outcomes

The information in the following tables is similar to that of traditional content learning outcomes statements that indicate what students should know and be able to do. The left column categorizes learning outcomes in terms of overarching themes that might be found in a data science course, and the middle column highlights learning outcomes.

Traditional mathematics and statistics lessons that teach concepts as a set of procedures and with a focus on procedural fluency can result in widespread disengagement as students see no relevance to their lives. The inability to see relevance in the content disproportionately impacts students of color and girls, who may also receive additional harmful messages that mathematics is not for them. It is crucial that students understand how data are used to explore real-world phenomena and investigate questions about socially and culturally relevant issues, using data-informed approaches and tools.

Modernized pathways in mathematics, statistics, and data science provide new opportunities to increase student interest in these courses, to empower students as learners, and to encourage students to continue their study of mathematics and related fields. In addition to content, instructors can offer social and emotional support to students through engaging lessons that allow students to connect with the ideas being taught. Content should be introduced, explored, mastered, and communicated in context. To that end, an additional column with examples is provided.

Learning Outcomes for a High School Data Science Course		
Overarching Themes	**Learning Outcomes**	**Proficiency Examples**
Multiple Representations (e.g., visualizations) of Data		
• Use data visualizations and summary statistics to explore the distribution for a single variable. • Use data visualizations and summary statistics for relationships between two and more variables (i.e., bivariate and multivariate relationships). • Understand that visualizing data can serve multiple purposes and use cases (i.e., informal explorations to formal presentations).	Students will be able to: • Interpret and produce univariate data visualizations and summary statistics to describe the distribution of a single variable, including the shape, center, spread, and presence of outliers. • Interpret and produce multivariable distributions to describe the relationship between multiple variables.	Ability to create clear, visually appealing graphics (with appropriate legends and attention to accessibility features) that: • Visualize descriptive statistics (e.g., histograms, box plots, and summary statistics), discerning between distributions and relationships. • Critically evaluate model effectiveness and biases. • Use visualization tools, such as Python (e.g., matplotlib), R (e.g., ggplot2), or Tableau.

Learning Outcomes for a High School Data Science Course		
Overarching Themes	**Learning Outcomes**	**Proficiency Examples**
• Identify the summary statistics and data visualizations that most meaningfully describe a given variable or set of variables. • Recognize features that can make data visualizations accessible to all students, particularly students with disabilities.	• Identify and critically evaluate summary statistics and data visualizations that meaningfully describe a distribution of a single variable or relationship between variables. • Use technology to produce data visualizations and incorporate features to increase accessibility.	• Can be used to communicate via different use cases and to multiple audiences, including: a. informal or semiformal exploratory data analysis (EDA) to identify distributions and identify outliers. b. observing trends in control variables and/or adding model parameters. c. visualizing and communicating insights to the public or other researchers.
Modeling Data		
• Interpret main findings from data models, considering contexts and relative proportions. • Evaluate what can and cannot be determined from a given experiment or analysis. • Use algebraic functions to construct single, bivariate and multivariate models for estimating a relationship in data. • Fit and interpret models to describe relationships between a response and one or more predictor variables.	Students will be able to: • Describe the findings from the results of their models and use these findings to draw relevant and justifiable conclusions, including necessary specifics and qualifiers (e.g., who conducted the study, under what conditions, how does that shape drawn conclusions). • Examine model fit (i.e., determine if the model is underfit or overfit), and spot the difference between model performance and the magnitude of the effect (i.e., significance versus effect size). • Spot common weaknesses and logical fallacies from experimental conclusions and interpretations (e.g., study misrepresentation in the media), paying careful attention to wording (e.g., differentiating between the null hypothesis, negative, "false," "unknown" results).	Ability to clearly describe model findings to: • Draw justifiable conclusions. • Identify potential flaws in experimental conclusions and interpretations. • Use technology for model fitting. • Effectively interpret model coefficients. • Evaluate predictor variables. • Select appropriate model types. • Calculate performance metrics. • Critically evaluate conclusions.

Learning Outcomes for a High School Data Science Course		
Overarching Themes	**Learning Outcomes**	**Proficiency Examples**
• Use models to predict new outcomes. • Identify the appropriate model for a given data set and analysis question. • Evaluate a model's performance and assess its usefulness for answering a given analysis question.	• Use technology to fit a variety of models (e.g., linear, logistic, decision trees) and interpret the model coefficients to describe the relationship between a predictor and response variable. • Use inference to determine which predictors are useful in the model. • Identify the appropriate model type (e.g., linear, logistic) based on the data and analysis question. • Calculate model performance metrics (e.g., root mean square error, accuracy, precision, recall) to evaluate how well a model fits a given data set, identify discrepancies in model performance, and critically evaluate the process and conclusions drawn from models produced by others.	
Problem Solving / Iterative Evaluation and Critique		
• Recognize that each data science project encompasses a full cycle, even if the student is not directly involved in every step. • Understand the steps for a full data life cycle from collecting data to communicating results. • Critically evaluate a data science workflow and analysis decisions. • Generate new questions that can be asked of the data.	Students will be able to: • Describe the steps of a data science workflow and apply the data science workflow to plan and execute their own data analyses. • Understand the steps of a full data science cycle from formulating a statistical investigative question to communicating results. • Question and validate the accuracy of their process (e.g., were any data left behind when merging datasets) and outputs (e.g., does the significance value and effect size of the result make sense). • Critically evaluate their own and others' workflows, identifying the potential impact of data analysis decisions on the results and conclusions.	Ability to clearly describe and apply steps in a data science workflow, including: • Recognizing that the data science process is iterative. • Critically assessing biases. • Using exploratory data analysis (EDA). • Qualifying findings, considering margins of error and uncertainty.

Learning Outcomes for a High School Data Science Course		
Overarching Themes	**Learning Outcomes**	**Proficiency Examples**
• Identify and quantify levels of uncertainty present in findings, based on sample size and variables included in the analysis.	• Use findings from exploratory data analysis to formulate follow-up questions that can be used to improve the dataset (e.g., cleaning), analysis (e.g., adding new variables), or data modeling process (e.g., findings that may challenge or add nuance to original hypotheses). • Qualify their study findings with error and uncertainty, from informal verbal qualifiers (e.g., only considered X many samples over Y groups and Z time periods) to software-assisted formal methods (e.g., adding error bars using Excel).	
Ethical Use of Data		
• Recognize how identity and personal experiences can influence the lens through which everyone views and interprets data. • Identify human values, assumptions, and worldviews encoded in products, methods, and systems that rely on data. • Design experiments to assess how various communities are impacted by data-based systems and practices. • Apply ethical reasoning in each step of the data analysis process. • Consider potential cultural and societal implications of data science work.	Students will be able to: • Recognize and critically evaluate how bias can impact every step of an analysis process, from data collection to communicating results. • Reflect on ways that they may view and analyze data from a specific perspective, recognizing that data analysis is not immune to human influence. • Critically evaluate familiar data-based systems (e.g., social media platforms, school district zones) to infer human values encoded in the system (e.g., who was the system designed for, what incentives do the creators have, what values are missing). • Use quantitative and qualitative methods (e.g., surveys, interviews, online research) to assess human impacts of data-based systems, measuring factors that matter to communities that they are familiar with (e.g., health, wellbeing, human rights). • Carefully consider the ethical implications of analysis decisions made by themselves and others (e.g., ethical considerations when scraping data from the web).	Ability to critically evaluate human and machine bias by: • Reflecting on one's personal biases. • Evaluating data systems for human values. • Employing methods to assess societal impacts. • Considering ethical implications. • Articulating cultural impacts. • Advocating for transparency. • Applying ethical frameworks. • Identifying frameworks for debating the pros and cons of different data applications.

Learning Outcomes for a High School Data Science Course		
Overarching Themes	**Learning Outcomes**	**Proficiency Examples**
• Understand the importance of transparency in data science work. • Evaluate data models for bias, fairness, and omission of relevant variables. • Argue for cases where data-based systems and practices should not be adopted, relying instead on human/environmental impacts and ethical frameworks.	• Describe the potential cultural and societal impact of a given data science project, particularly how it can impact people from minoritized groups (e.g., impact of recidivism or sentencing models). • Explain the importance of being transparent about each step of the analysis process (e.g., how missing data were handled) and practice transparency in their own work. • Critically evaluate decisions regarding transparency in data science algorithms and data (e.g., black box algorithms, when sharing data may violate privacy concerns). • Apply human impact and ethical frameworks to critique modeling approaches with an understanding that an approach that may work well for one population may not work for another (e.g., collecting data from students in after-school activities may exclude lower income students). • Given an existing application of a data-based system (e.g., a district that chooses to provide ChatGPT for homework help), identify applicable ethical framework(s) to use in debate with their peers to identify and articulate pros and cons of the application.	
Drawing Conclusions From Data		
• Understand how data are used to explore real-world phenomena and investigate questions about socially and culturally relevant issues, using a data-informed approach.	Students will be able to: • Identify the variable(s) and analysis methods to investigate a question about a real-world phenomenon, and apply a data science cycle to derive data-informed conclusions about socially and culturally relevant issues. • Explain the meaning and difference between correlation versus causation and what can be claimed from each. • Describe the extent to which a given result can be generalized, and list reasons why it can or cannot concurrently.	

Learning Outcomes for a High School Data Science Course		
Overarching Themes	**Learning Outcomes**	**Proficiency Examples**
• Describe the scope of conclusions that can be made from different analysis procedures. • Use analysis results to make data-informed decisions. • Identify recommendations based on the findings, supported by data.	• Provide alternative explanations for a given result, listing potential confounding factors and describing what factors may mitigate the same alternative explanations. • Describe the findings from the results of their models and use those findings to draw relevant and justifiable conclusions, including necessary specifics and qualifiers. • Use simulation-based inferential methods to draw conclusions and make data-informed decisions. • Use the findings and conclusions of their models to suggest actions, changes, improvements, or follow-up studies. • Present their findings to multiple audiences who are situated to benefit from their recommendations.	Ability to justify the selection of variables and analysis methods for real-world investigations by: • Describing model findings justifiably. • Using simulation-based methods. • Proposing actions based on conclusions. • Presenting findings to multiple audiences.
Effective Communication		
• Effectively communicate analysis results to a nontechnical audience. • Explain results in the terms of prior assumptions and new knowledge. • Construct data-informed arguments, recognizing the potential limitations. • Justify the analysis process and decision making.	Students will be able to: • Write reports that incorporate analysis output and narrative about the process and conclusions. • Identify creative ways to communicate data analysis results (e.g., video, infographics, interactive tools). • Quantify measures of uncertainty (e.g., margin of error) and explain what the uncertainty means as they communicate results. • Articulate potential limitations in their data and/or analysis processes and how those limitations should be taken into account when considering the conclusions. • Describe their analysis process and results without overly relying on jargon.	Ability to create reports that clearly integrate outputs with narrative text by: • Using creative communication methods. • Quantifying uncertainty. • Articulating limitations. • Describing analyses without excessive jargon.

Learning Outcomes for a High School Data Science Course

Overarching Themes	Learning Outcomes	Proficiency Examples
Using Technology		
• Use technology to visualize, wrangle, and analyze data. • Access relevant online datasets/data information (i.e., via spreadsheet imports or API calls). • Apply ethical reasoning to use technology responsibly, including artificial intelligence. • Develop reproducible analyses. • Use technology to collaborate on a team.	Students will be able to: • Use computational tools that are commonly used for analysis, using code-based tools where possible. These tools will be accessible outside of class. • Access relevant datasets that are updated at appropriate intervals. • Evaluate the ethical implications of how technology is being used (e.g., where data are stored). • Explain the ethical considerations of using AI and make decisions on how to use it in their data science work. • Understand the value of reproducible data analysis, and incorporate documentation and other reproducibility practices, as allowable with the available technology. • Use collaborative tools (e.g., Google Docs, GitHub) for effective collaboration.	Ability to use common computational tools effectively and efficiently: • Produce reproducible analyses. • Access online datasets (e.g., via API calls, web scraping). • Visualize, wrangle, and analyze data... all while applying and considering the ethical implications of technologies, and using collaborative platforms for efficient teamwork.
Collecting and Working With Complex Real-World Data		
• Collect and manage data to answer a question of personal interest. • Evaluate costs and risks of data collection, ranging from adverse human impacts to privacy concerns and environmental waste. • Use a wide range of data collection tools. • Identify gaps, assumptions, and areas of improvement for data collection.	Students will be able to: • Identify relevant and trustworthy data sources for a general topic or question, justifying the appropriateness of each data source for the problem while balancing pros and cons, including uniqueness, bias, and sampling methods. • Critically evaluate data collection methods with attention towards factors such as harm to experimental subjects. • Choose an appropriate methodology to efficiently collect and organize data, and evaluate the pros and cons of different approaches.	Ability to clearly and accurately: • Identify relevant and trustworthy data sources with multiple variables (both bivariate and multivariate). • Critically evaluate collection methods. • Choose appropriate methodologies for given contexts. • Critique methods and merge datasets. • Clean and format data. • Extract insights from nontraditional sources.

Learning Outcomes for a High School Data Science Course		
Overarching Themes	**Learning Outcomes**	**Proficiency Examples**
• Clean and wrangle messy data to prepare them for analysis. • Understand and derive insights from various forms of data, including nontraditional data, such as text and images.	• Critique data collection approaches to address problems, such as data ownership, missingness, and weaknesses in variable formulation (e.g., aggregating multiracial individuals into a "two or more races" category that obfuscates identity), paying attention to power dynamics that may lead to incomplete or skewed data. • Join multiple data sets, clean messy data (e.g., handle missing values), and put them in a "tidy" format that can be analyzed by software. • Identify features that can be extracted from nontraditional data, such as identifying and explaining areas of subjectivity (e.g., "danceability" of a song) in order to derive insights.	
"Habits of Mind" to Become an Effective Collaborator and Lifetime Learner		
• Target increases in measurable persistence and problem attempts. • Continually seek new information, skills, and techniques. • Consider multiple solutions and multiple techniques when confronted with novel problems.	Students will be able to: • Use strategies for overcoming challenges in understanding conceptual ideas, analyzing data, or using technology. • Recognize and use learning strategies to keep learning data science. • View data science as a creative endeavor and be encouraged to think "outside of the box" and try new things, particularly on open-ended assessments, such as a final project.	Ability to confidently: • Express an appreciation for data science tools, methods, and principles. • Reflect on learning experiences. • Identify effective learning strategies for ongoing data science education. • Think innovatively about data problems and solutions.

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