The University of Texas at Austin
Charles A. Dana Center

Statistics 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 statistics course framework describes a non-AP statistics course that integrates statistical and data literacy concepts and strategies to empower students to live skillfully and productively in our data-driven society. As students engage with course content and identify issues in their worlds to explore, they will approach solutions from multiple perspectives. Students will compare and contrast mathematical and statistical approaches to problem solving, which will enable them to develop a deeper understanding of the benefits and challenges of each approach.

This framework, which includes design principles and learning outcomes, is intended to guide in the development of high-quality instructional materials that will further cultivate students' statistical habits of mind, provide the opportunity for students to develop the statistical reasoning essential for making the data-based decisions needed to function in today's data-rich world, and prepare them for success in college-level statistics.

The modern practice of statistics necessitates the use of computing and software. It is not reasonable to rely entirely on a graphing calculator or Excel, as this statistics course focuses on learning from real data and authentic contexts, exploring multivariable relationships, and communicating results through a variety of data visualizations. The design of this course should incorporate the use of a statistics software or freely available statistics applications.

All students who have successfully completed Algebra 1 and Geometry, or Integrated Math 1 and 2, are prepared to enroll in a non-AP statistics course. Successful completion of that course signals readiness for college-level statistics as well as continued study in any other secondary mathematics pathway (algebraic, statistics, quantitative reasoning, or data science).

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 nurturing a discerning approach to statistical and/or computational analyses and interpretation, evaluating datasets, 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 diverse 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

The design principles that follow describe how curricular materials should be structured and implemented to support a coherent and engaging student 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—who feel disconnected from mathematics and disaffected by the learning process—should be given the opportunity to develop their mathematical and statistical reasoning abilities while engaging in meaningful, authentic work.

Curriculum designers should develop curricular materials and professional learning for teachers that reflect all aspects of these design principles. 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 statistics and data, and to think critically about how content is contextualized and delivered. We hope that teachers come to class each day knowing that their time will be purposeful and impactful. They should feel empowered to adapt materials to be responsive to their students' identities, lived experiences, and aspirations, and to prepare students to successfully navigate evolving tools, norms, and problems in dynamic work environments. Ultimately, teachers should find joy and passion in their work as students engage more deeply with content that matters to them; teachers should feel confident in their ability to recognize and facilitate students' understanding of statistics and data.

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 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 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 statistics 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).
- Foster respectful peer discussions.
- Provide students with opportunities to engage in critical thinking and to explain their reasoning and justify conclusions.
- Provide students with opportunities to engage in the four-step data investigation cycle, including formulating questions that can be answered with data; collecting or assembling data that can answer these questions; analyzing the data; and interpreting and summarizing conclusions from the data.
- Use technology to explore and investigate to develop conceptual understanding.
- Allow flexibility to use additional, research-based pedagogical approaches.
- Support questioning that encourages thinking, metacognition and self-help behaviors.
- Incorporate strategies that position mistakes and failed strategies as opportunities to learn, and encourage self-monitoring and help-seeking behaviors.
- Cultivate resilience, agency, and positive mathematical identities in all learners.

Equitable Pedagogy (cont.)

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

- Foster a culture of both joy and intellectual challenge in their classrooms, centering on rich conversations about data and concepts.
- Support active discussion and engagement, using a variety of active learning instructional methods such as inquiry, small group collaborative work, and hands-on and technology-based activities.
- When appropriate, provide hands-on activities and physical simulations prior to using software and applications so that students understand what the technology is doing.
- Provide activities and tasks with multiple, accessible entry points that offer meaningful opportunities for student exploration and co-creation of understanding.
- Anticipate where students might struggle and support them productively through the struggle, providing instruction and information about the role of productive struggle in learning.
- Discuss and refer to the purpose and goals of the lesson so that students understand how the current work contributes to their learning.
- Provide students with regular, scaffolded opportunities to self-monitor, evaluate, and reflect on their learning, both individually and with their peers.
- Monitor student progress and make needed accommodations, offering remediation and enrichment and differentiating instruction, when appropriate.
- Facilitate explicit connections between student approaches, reasoning, and, as appropriate, more efficient methods.
- Advance student understanding by asking questions that build on, but do not limit, student thinking and that go beyond gathering information to probing thinking and requiring explanation and justification.

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

- Make sense of new concepts and tasks, including making connections to their prior understanding and work from previous courses, and by applying and building on previously learned problem-solving strategies.
- Develop their ability to work productively individually and in teams, including helping one another by sharing strategies and solution methods and by developing strategies collaboratively.
- Persevere in exploring difficult concepts and challenging tasks.
- Use mathematical, statistical, and technology tools and representations to support their thinking and problem solving and to develop conceptual understanding.
- Be willing to make and learn from mistakes.
- Use "look back" and alternative solution methods to support or reconsider solutions.
- Assess and monitor their own understanding and progress, with a focus on course learning goals.
- Draw on multiple sources of knowledge, including mathematics, statistics, culture, language, and family.

Equitable Learning Environment

An equitable learning environment is inclusive and supports 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—fosters 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.
- Value student input and promotes curiosity that encourages exploration.
- 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.
- Create opportunities for both independent and collaborative student work, positioning the teacher as a facilitator.
- Demonstrate what students are learning is valuable outside of the classroom, highlighting statistics as a necessary tool to model (using a variety of representations) and solve problems that arise in the real world.
- Provide resources, such as videos in which professionals discuss and demonstrate how they use statistics in their work.
- Incorporate opportunities for students to develop and apply metacognitive strategies (planning, monitoring, evaluating, and reflecting on their learning) and to set and monitor goals.
- Facilitate teacher reflexivity in how their power and authority influence the learning environment and impact students.

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

- Create a safe, student-centered learning environment in which all students feel a sense of belonging to the class and the discipline, and are not afraid to take risks or make mistakes.
- Offer low-stakes and/or no-stakes formative assessment and help students realize that confusion and errors are a natural part of learning by facilitating discussions on mistakes, misconceptions, and struggles.
- Position students as self-sufficient learners while focusing on facilitation, monitoring thinking, and pushing students to higher level skills.
- Value reasoning and problem solving shared by students, and wait for students to clarify others' thinking.
- Motivate students' learning of concepts through opportunities for exploring and solving problems that build on and extend their current understanding.
- Allocate substantial instructional time for students to decide which representation(s) to use, and to discuss and make connections among representations.
- Illustrate the relevance of the content through data and quantitative information from compelling contexts.

Equitable Learning Environment (cont.)

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

- Take responsibility for making sense of tasks by drawing on and making connections with their prior understanding and ideas.
- Work effectively to monitor their own progress and test their own assumptions in their analyses.
- Accept and expect that their peers will use a variety of solution approaches and that they will discuss and justify their strategies with one another.
- Help to shape others' thinking in supportive, collegial ways, and accept the same support from others.
- Persevere in solving problems and realize it is acceptable to say, "I don't know how to proceed here" and then seek help from appropriate sources including their peers.
- Be comfortable reflecting on mistakes and misconceptions, approaching them as learning opportunities to improve their understanding.

Equitable Communication

Equitable communication is essential in high school mathematics, particularly statistics 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...

- Provide students with opportunities to develop their ability to read and communicate about and with statistics and data in authentic contexts, using written, symbolic, visual, and oral formats.
- Allow students to demonstrate understanding, using various forms of communication.
- Provide guidance on supporting students in moving from self-created to standard terms and definitions.
- Provide students with opportunities to make their thinking visible as they communicate results and justify conclusions.
- Provide models of complete and effective communication of results and justifications.
- Provide students with opportunities to analyze and critique presentations of statistical information.
- Foster effective dialogue and constructive feedback among students as a method for refining or revising views when evidence warrants.

Equitable Communication (cont.)

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

- Develop greater confidence in their own understanding of students' statistical skills, and use information gathered from student communication to make just-in-time adjustments to instruction.
- Scaffold instruction to support students in developing necessary skills in reading, writing, and oral communication.
- Support student growth in discipline-specific use of statistical terminology and notation.
- Support students in developing active listening skills and in asking clarifying questions to their peers that deepen understanding.
- Provide students with regular opportunities to write about and discuss statistics within authentic, relevant, contextualized tasks.
- Facilitate discourse among students by positioning them as authors of ideas who explain and defend their approaches, using varied representations.
- Incorporate pauses to allow time for students to formulate responses to teacher questions and peer comments.
- Foster effective whole class discussion by selecting and sequencing student approaches and solution strategies.
- Facilitate discussions that make explicit connections between student approaches, reasoning, and, as appropriate, more efficient procedures.

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

- Develop greater confidence in their active listening and communication skills.
- Effectively communicate ideas, assumptions, reasoning, representations, and conclusions to one another in pair, small group, and whole class discourse and, when appropriate, to external audiences.
- Expect to be asked to explain, clarify, and elaborate on their thinking, using written, visual, and oral formats.
- Accept and act on appropriate constructive feedback, and suggest refinements to instruction when appropriate.
- Experience growth in moving from self-created language to clarity and precision with discipline-specific terminology.
- Seek to understand the approaches used by peers by asking clarifying questions, trying out others' strategies, and describing the approaches used by others.
- Identify similarities and differences in approaches, using examples or counterexamples to support or refute arguments.
- Analyze and critique presentations of statistical information.

Equity in Tools and Technology

Equity in tools and technology requires that all materials and tools are available and 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 to ensure equitable access and engagement with the course content.

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

- Position technology as a fundamental tool but not the focus of the learning.
- Acknowledge unequal student access to digital tools and internet connectivity, and consider varying levels of student technology literacy (i.e., prior exposure to technological tools).
- Ensure accessibility while enabling students to have access to a range of tools and experiences, giving students agency in the selection of tools where appropriate.
- Use technology and statistical software and applications that are freely available, easy to use, accessible across platforms and devices, and robust to multiple contexts and data set sizes, with ongoing accessibility to students after the class ends.
- Engage students in the effective use of technology for data analysis.
- Where appropriate, use hands-on activities and physical simulation prior to introducing computer applications so that students understand what the applications are doing.
- Include tasks that engage students in visualization and exploration to develop conceptual understanding, communicating concepts in interactive, dynamic, and responsive ways.
- Do not overload teachers and students with unnecessary technological tools.

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

- Focus less on leading students through procedural calculations (handled by technology) and more on determining assumptions and inputs, and on interpreting outputs and results.
- Use student-centered teaching practices and technology to assist students in visualizing and understanding important statistical concepts.
- Introduce students to various data analysis and visualization tools that students can use beyond the classroom and support them in understanding the best uses for each tool.
- Empower students to be creative and to use technology in support of their own goals, leveraging technology as a tool that can expand the scope of real-world problems and data that students can investigate.
- Be comfortable in learning alongside students since teachers are not experts in the use of every technology.
- Be willing to experiment in response to students' questions by modeling good practices for seeking answers to such questions.
- Be sensitive to each student's specific needs to make devices and internet access available equitably.

Equity in Tools and Technology (cont.)

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

- Use technology to visualize and understand important concepts and to support data-based conclusions.
- Create data visualizations, analyses, and reports that clearly communicate their thinking and conclusions.
- Use modern tools that prepare them for what they may see in college or the workplace and that allow them to gain experience to learn new tools in the future.
- Use technology to carry out investigations that might otherwise be too difficult or time-consuming.
- Consider the relative usefulness of a range of tools in particular contexts and choose from a variety of tools appropriate for a given task.
- Understand that the use of technology does not replace the need to evaluate the reasonableness of conclusions or assess whether the conclusions apply in a given context.
- Focus their cognitive load on critical interpretation rather than on procedural calculations that can be handled by 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, students should be given opportunities to critique the biases of the functioning technologies (e.g., generative AI models such as ChatGPT) and quantitative methodologies (e.g., predictive algorithms) to develop their critical thinking skills. Applying a critical lens when evaluating and interpreting data sets is essential, 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...

- Are scaffolded and accessible to learners from varied backgrounds.
- Are diverse, relevant, and authentic.
- Align with student interests.
- Reflect the experiences of diverse student populations.
- Position the work as preparation for a variety of pathways and careers.

Equitable Contexts (cont.)

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

- Provide students with opportunities to share their personal backgrounds and interests, including cultural and societal values, and help make the connection between what is important in students' lives and future aspirations and what they are learning in class.
- Provide interesting and real (not contrived) data sets and tasks, both in class and on assessments, including those that are local to students.
- Facilitate exploration of problems from a variety of academic disciplines, programs of study, careers, and cultures.
- Focus less on classroom management and more on channeling the engagement that naturally comes from relevant contexts.

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

- Genuinely engage with course content, pushing their own understanding towards a meaningful objective.
- Actively seek and describe connections between classroom experiences and the world outside of class (including their own personal experiences).
- Develop critical thinking skills in key areas of civic reasoning, financial literacy, and risk assessment.
- Learn about new pathways, careers, and opportunities they can explore in the future.
- Use statistical modeling to carry out investigations related to their own interests or backgrounds.
- Examine the ways in which data are collected in their day-to-day lives, and consider the ethics and consequences of collecting and using data to make decisions.

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 lesson activities, assessments, and teacher support materials that...

- Align with course learning outcomes and course design by valuing conceptual understanding and student growth, and by prioritizing open-middle and open-ended items with diverse and relevant contexts.
- Allow for multiple ways of demonstrating understanding and reasoning by employing a variety of assessment methods (e.g., projects, portfolios, presentations) that summarize thinking processes and results from the application of the data investigative process.
- Are consistent with equitable grading practices, such as no-stakes assessments and allowing students to revise and resubmit work.
- Have diversity in the context and datasets used.
- Are designed to give students choice over the tasks/contexts they engage in.
- Allow for flexibility in assessment items contexts so that teachers can use assessment items that are relevant to their students.
- Are designed to go beyond focusing solely on correctness by considering new ways to measure approximations of knowledge, such as considering the strength of student arguments.
- Where appropriate, include robust feedback loops so that students have the opportunity to revise their work (without penalty to a grade) based on teacher/peer feedback.
- Include task-specific rubrics where appropriate.
- Are embedded with daily formative measures in appropriate places to yield actionable data to lead to improved learning.
- Identify the intended informational purpose of each item (e.g., whether it measures conceptual understanding, procedural fluency, selecting appropriate strategy).
- Create structures for teachers to periodically analyze student performance data.

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

- Value assessment primarily as an opportunity to learn about student understanding and to adapt and improve instruction.
- Monitor students' progress to make immediate and longer term instructional modifications.
- Embed assessments in daily routines and activities, and use ongoing formative assessments that value the journey. Reward and encourage growth.
- Use multiple forms of assessment that capture both conceptual understanding and procedural fluency.

Equitable Assessment (cont.)

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

- Provide students with opportunities to think about and refine their thinking based on feedback from other students and teachers.
- Use task specific rubrics for clarity.
- Think critically about their own perceptions of student strengths and weaknesses in order to provide appropriate targeted instruction.

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

- See assessments as purposeful exercises that contribute to their learning.
- Use evidence of their understanding to advance their own learning and to prepare for summative assessments.
- Think about and refine their thinking based on feedback from peers and teachers.
- Demonstrate their thinking in multiple modalities, including ones that align with their strengths and ones that push them to grow in areas where they can improve.
- Have voice and agency in how they demonstrate growth and proficiency.
- Show evidence of growth and mastery through portfolios that highlight process, product, and reflection.

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 diverse needs of their students.

Designers will develop comprehensive professional learning that...

- Builds an equity mindset in teachers via ongoing professional learning so that teachers recognize the need for math pathways.
- Is based on research-supported teaching practices.
- Is asset-based.
- Models effective teaching practices.

Equity in Professional Learning (cont.)

Designers will develop comprehensive professional learning that...

- Involves active participation in a supportive, collaborative environment.
- Emphasizes the importance of formative assessment.
- Provides teachers with opportunities to learn to work with authentic, real-world data sets in the context of applying the data investigative process.
- Provides teachers with regular opportunities to reflect on their learning and teaching practices and on how classroom practices are viewed by and impact all students.
- Introduces culturally responsive and sustaining pedagogical theory and strategies so that teachers can understand how different cultures can be supported in, and can contribute to, the classroom environment.
- Integrates technology appropriately, providing instruction as needed.
- Includes cycles of classroom implementation.
- Is distributed over time.
- Is adaptable in terms of delivery methods.
- Leverages the expertise of district leaders, school leaders, and teachers.
- Meets the unique needs of the districts, schools, and teachers.

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

- Feel more confident in areas that are not traditionally emphasized in their own professional training, such as data analysis and data technology.
- Combine knowledge of students (e.g., challenges and misconceptions, interests, and motivations) and knowledge of teaching (e.g., design of instruction, sequencing of content, choice of examples, representations) with knowledge of content to support student learning and growth.
- Understand the value of technology and other active learning practices in developing conceptual understanding.
- Demonstrate the value of and the differences between different tools and technologies, and support student growth in selecting an appropriate tool for a given task.
- Gain skills and practices to enhance facilitation and responsiveness to students and to eliminate barriers to learning, sharing responsibility for improving learning for each and every student.
- Develop and leverage a growth mindset about each and every student's ability to engage with statistical concepts deeply through the understanding and implementation of appropriate pedagogical content knowledge.
- Embrace inclusive practices that build on what students bring to the classroom in terms of experiences, talents, and interests rather than seeing differences as weaknesses.
- Engage in a cycle of ongoing professional learning, including opportunities to regularly engage with other educators who teach the course either in-person or virtually in communities of practice.

Equity in Professional Learning (cont.)

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.
- Become agents of their own learning, interrogating data and processes, and redirecting.
- Develop positive identities built on self-efficacy, self-evaluation, and reflection.

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 statistics course, and the right column highlights learning outcomes.

Modernized pathways in mathematics, statistics, and data science provide new opportunities to increase the number of students who extend their exploration of mathematics. 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.

This statistics course provides new opportunities to increase diversity, to empower students as learners, and to encourage them to continue their study of statistics and related fields. In addition to content, educators can offer social and emotional support to students through engaging lessons that allow students to connect with the ideas being taught.

Data Literacy: Exploring and Visualizing Data

Learning Outcomes

Students will be able to:

- Categorize variables as quantitative or categorical given a multivariable data set.
- Identify misleading features in graphs, including distortion of axis scales, use of multidimensional pictographs, and use of convenient domains.
- Visualize and summarize distributions of a single categorical variable, using raw counts and relative frequencies.
- Visualize and summarize bivariate categorical data, using tables, segmented bar plots, and mosaic plots to reason about marginal and conditional relative frequencies.
- Identify and describe the potentially misleading effects resulting from Simpson's Paradox.
- Describe the advantages and disadvantages of different summary statistics for categorical data.
- Visualize and summarize distributions of a single quantitative variable, including numerical summaries such as the five-number summary (minimum, the first quartile, median, the third quartile, maximum), mean, median, interquartile range, standard deviation, and range, and graphical summaries such as dotplots, histograms, and boxplots.
- Describe the shape of distributions of a single quantitative variable and identify outliers.
- Identify and describe the advantages and disadvantages of different summary statistics for quantitative data, and determine which measure of center or variability is most appropriate in a given situation.
- Visualize and describe distributions of a quantitative variable for different values of a categorical variable, including parallel dotplots and boxplots.
- Use measures of relative standing, such as z-scores and percentiles, to describe the location of individual variable values.

Study Design: Causation and Generalizability

Learning Outcomes

Students will be able to:

- Distinguish between a sample and population, and identify the population to which generalization from a random sample is reasonable.
- Identify biases that arise from nonrandom sampling methods, including selection bias, voluntary response bias, and nonresponse bias.
- Describe feasible methods for selecting a simple random sample that can be used to generalize to a population of interest.
- Evaluate the statistical and practical tradeoffs between different random sampling methods, including simple random sampling, stratified random sampling, and cluster sampling.
- Differentiate between observational studies and experiments, recognizing the role of random selection in observational studies and of random assignment in experiments.
- Explain the difference between association and causation.

Study Design: Causation and Generalizability (cont.)

Learning Outcomes

- Design an experiment that allows for causal inference, and describe how the design incorporates random assignment to groups and comparison after treatment.
- Describe the purpose of blinding and of including a placebo or control group in the design of an experiment.
- Identify natural experiments and rare cases in which causal conclusions can be made from observational data.
- Evaluate practical and ethical considerations in the study of human subjects, including the ethics of informed consent and approval, and personal data privacy.
- Simultaneously evaluate the generalizability and type of inference (causal or not) that are appropriate for a given a study.

Understanding Chance: Probability

Learning Outcomes

Students will be able to:

- Calculate probabilities of events with equally likely outcomes.
- Estimate probabilities, using simulation based on the law of large numbers.
- Use Venn diagrams, two-way tables, and tree diagrams to visualize, calculate, and interpret the probability of unions, intersections, and complements of events.
- Calculate and interpret the probability of independent and dependent sequential events.
- Calculate and interpret conditional probabilities.
- Estimate and interpret the expected value and standard deviation of a discrete random variable.
- Use the empirical rule to estimate probabilities and values for normal distributions.
- Use z-scores and technology to calculate probabilities and values for normal distributions.

Understanding Chance: Statistical Significance

Learning Outcomes

Students will be able to:

- Use simulation to informally test a claim about a proportion based on reasoning with an estimated p-value.
- Use simulation to investigate the effect of sample size and biased sampling when making inferences.
- Describe and check the conditions necessary for using the normal distribution to approximate the sampling distribution of a sample proportion.
- Use a normal approximation to informally test a claim about a proportion.
- Use a normal approximation to create and interpret confidence intervals for a proportion.

Understanding Chance: Statistical Significance (cont.)

Learning Outcomes

- Use simulation to create and interpret confidence intervals for a proportion.
- Use simulation to approximate the sampling distribution of the difference in two proportions and use a simulated p-value to investigate the statistical significance of the difference between two proportions.
- Use simulation to create and interpret a confidence interval for the difference between two proportions.
- Describe the problem associated with conducting multiple tests and identify conditions that can create the problem.

Modeling Data: Making Predictions

Learning Outcomes

Students will be able to:

- Describe the strength and direction of relationships between two quantitative variables.
- Use technology to fit a linear regression model to bivariate quantitative data.
- Interpret the slope and y-intercept of a regression line in context.
- Use an estimated simple linear regression model to predict a y-value for a given x-value, and calculate and interpret residuals.
- Describe the strength of a linear relationship, using r and r^2.
- Use technology to fit a polynomial model to a nonlinear relationship between two quantitative variables.
- Evaluate predictive models, using train and test sets of data.
- Tune predictive models and evaluate tradeoffs between overfitting/underfitting, using test datasets and r^2.

Putting It All Together

Conduct a Study • Critique a Study• Build a Predictive Model

Learning Outcomes

Students work in groups on a final project.

Groups can choose between the following options:

- Conduct their own study: Collect their own data and perform their own analysis.
- Critique a study: Assess the strengths and weaknesses of a published study's data collection, design, and analysis.
- Build a predictive model: Tune a polynomial model based on a large dataset to make predictions about unseen data.

Putting It All Together (cont.)

Conduct a Study • Critique a Study• Build a Predictive Model

Learning Outcomes

The following learning objectives will span the above options.

Students will be able to:

- Clearly communicate the results of a data analysis or model.
- Appropriately tailor their level of technical communication, based on their audience.
- Assess limitations and pitfalls of a data analysis or model.
- Work effectively in teams to divide labor, collaborate in analyses, and create a product of higher quality than any one individual's work.

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