



**SENATE COMMITTEE ON CURRICULAR AFFAIRS**  
**COURSE SUBMISSION AND CONSULTATION FORM**

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*Principal Faculty Member(s) Proposing Course*

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Name	User ID	College	Department
BENJAMIN LEAR	bul14	Science (SC)	Not Available

Academic Home: Science (SC)

Type of Proposal:  Add  Change  Drop

Course Designation

(SC 103N) When Data Meets Design

### Course Information

Cross-Listed Courses:

Prerequisites:

Placement into Math 22.

Corequisites:

Concurrents:

Recommended Preparations:

Abbreviated Title: Data Meets Design

Discipline: General Education

Course Listing: Inter-Domain

### Special categories for Undergraduate (001-499) courses

Foundations

Writing/Speaking (GWS)

Quantification (GQ)

Knowledge Domains

Health & Wellness (GHW)

Natural Sciences (GN)

Arts (GA)

Humanities (GH)

Social and Behavioral Sciences (GS)

Additional Designations

Bachelor of Arts

International Cultures (IL)

United States Cultures (US)

Honors Course

Common course number - x94, x95, x96, x97, x99

Writing Across the Curriculum

First-Year Engagement Program

First-Year Seminar

Miscellaneous

Common Course

#### GE Learning Objectives

GenEd Learning Objective: Effective Communication

GenEd Learning Objective: Creative Thinking

GenEd Learning Objective: Crit & Analytical Think

GenEd Learning Objective: Global Learning

GenEd Learning Objective: Integrative Thinking

GenEd Learning Objective: Key Literacies

GenEd Learning Objective: Soc Resp & Ethic Reason

#### Bulletin Listing

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**Minimum Credits:** 3  
**Maximum Credits:** 3  
**Repeatable:** NO  
**Department with Curricular Responsibility:** Chemistry (UPSC\_CHEM)  
**Effective Semester:** FA 2018  
**Travel Component:** NO

#### Course Outline

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##### **A brief outline or overview of the course content:**

This course focuses on bringing together knowledge in the areas of design, science, data handling, and data presentation. The particular focus is on the creation, interpretation, and critical analysis of data visualizations. Such visualizations are a common part of modern life, and students will be expected to both consume and create them throughout their careers.

Students taking this course will be introduced to the history of data visualizations, which will be used to place current visualization methods in context. The students will then explore how these visualizations are made, with a focus on the individual design elements that come together to form an effective data visualization. We will also discuss how these design elements can be manipulated in order to bias interpretation of data, so that the students are aware of the importance of critically analyzing the visualizations they encounter in their daily life.

In addition to learning to interpret and critique data visualizations, the students will also create their own visualizations -- using the design concepts discussed throughout the course. Here the focus will be on choosing an explanation that is supported by a dataset and then iteratively designing and creating data visualizations until this explanation is communicated effectively by the visualization. The key outcome will be to provide the students a powerful tool that they can use to craft effective and compelling data-driven arguments -- a skill that is applicable across a wide variety of fields and careers.

All of the above work will rest upon an ability to identify or acquire data sets appropriate for answering quantitative questions. Thus, the students in this course will also be trained in how to find or generate such datasets. Furthermore, the students will explore basic ways to analyze data, including measurements of central tendency, ranges, and the methods by which inferences are drawn from data.

##### **A listing of the major topics to be covered with an approximate length of time allotted for their discussion:**

Below are major topics. As a note: they are not presented in chronological order. The course will strive to interweave these topics, in order to highlight the connection between data and design in creating and consuming data visualizations.

Importance of data visualizations in the modern world (1 week):

We will consider many examples of modern data visualizations. The presentation will focus on differences in visual appeal and how these differences relate to ease of understanding the visualization. This effort will be used to motivate the rest of the course.

History of data visualizations (2 weeks):

We will trace the history of data visualizations from early Mesopotamia through the current emphasis on 'big data.' The focus will be on the continual push towards greater clarity in representation of data, and the various schools of thought that have emerged regarding the marriage of design and data.

How to ask scientific questions and answer them with data (2 weeks):

We will introduce the scientific method, and then frame this method in terms of asking answering questions using numbers. We will introduce different approaches to population sampling and experimentation, and also focus on the analysis of data that underlies data visualizations.

Major types of data visualizations and how they are constructed (3 weeks):

We will introduce several major classes of data visualization (bar charts, histograms, scatter plots, line graphs, etc.) and compare and contrast their utility for conveying explanations for different questions. Focus will be on the connection between the design of these visualizations and the explanations they are attempting to convey. We will take both high-level (i.e., categorical) views, as well as detailed views at the basic elements of these plots (axes, tick marks, data markers, typography, etc.) and how these elements combine to make effective visualizations.

Creation of data visualizations from data (4 weeks):

We will practice implementing our understanding of the treatment of data and design to create effective and compelling data visualizations. This will involve critiquing of peer's works.

How data visualizations can be manipulated (1 week):

We will discuss how each of the design elements of data visualizations can be chosen in such a way as to influence the interpretation of the underlying data. The focus will be on developing a habit of critically analyzing data visualizations and the skills required for such analysis.

Drawing inferences from data and representing these in graphical form (2 weeks)

We will discuss the means by which we can draw inferences from data. Focus will be on regression and correlation analysis. We will discuss the power, limitations, and underlying assumptions that go into this analysis as well as how we can represent each of these concepts graphically.

### **Course Description:**

The student will become an effective generator and consumer of the data visualizations that saturate public and professional discourse. The student will examine the rules of design and how they can be used to construct compelling visualizations of data. The student will use this knowledge to critique data visualizations from the media and their peers. The student will produce data visualizations of their own using data sets that they generate and analyze. Though the focus throughout the course will be on natural science, we will also consider data relevant to areas such as business, science, history, education, and politics. The student will emerge from this course with an appreciation of how data visualizations influence their life, as well as the skill set to craft persuasive visualizations to support issues of interest to them.

For the purposes of this course no prior knowledge is assumed in science, data handling, or design. We will build the knowledge and vocabulary needed in order to pair these two domains and equip you with a lifelong tool for creating persuasive data-driven explanations.

### **The name(s) of the faculty member(s) responsible for the development of the course:**

1 Name: BENJAMIN LEAR (bul14)

Title: Associate Professor of Chemistry

Phone: 814-867-4625

Address: 126 Davey Laboratory

Campus: UP

City: University Park

Fax:

## **Course Justification**

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### **Instructional, Educational, and Course Objectives:**

**This section should define what the student is expected to learn and what skills the student will develop.**

#### **COURSE LEARNING OBJECTIVES**

Upon completing this course, students will be able to:

- 1 - Explain the historical and current importance of data representation.
- 2 - Formulate questions that can be answered quantitatively.
- 3 - Design and implement plans to gather data that answers quantitative questions.
- 4 - Use rules of design to craft compelling data visualizations.
- 5 - Critically analyze data visualizations.

Because this course brings together the GA and GN knowledge domains in a general education course, the course targets specific areas of these knowledge domains and general education.

#### **GENERAL EDUCATION**

GE1: Effective communication – the ability to exchange information and ideas in oral, written, and visual form in ways that allow for informed and persuasive discourse that builds trust and respect among those engaged in that exchange, and helps create environments where creative ideas and problem-solving flourish.

GE2: Integrative thinking – the ability to synthesize knowledge across multiple domains, modes of inquiry, historical periods, and perspectives, as well as the ability to identify linkages between existing knowledge and new information. Individuals who engage in integrative thinking are able to transfer knowledge within and beyond their current contexts.

GE3: Critical and analytical thinking – the habit of mind characterized by comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating a conclusion. It is the intellectually disciplined process of conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

#### **GENERAL ARTS**

GA1: Demonstrate competence in the creation of works of art and design.

GA2: Demonstrate competence in analysis, critical thinking and interpretive reasoning through the exploration of creative works.

GA3: Demonstrate an expanded knowledge and comprehension of the role that the arts play in various aspects of human endeavor.

#### **GENERAL NATURAL SCIENCE**

GN1: Explain the methods of inquiry in the natural sciences.

GN2: Demonstrate informed understandings of scientific claims and their applications.

GN3: Evaluate the quality of the data, methods, and inferences used to generate scientific knowledge.

#### **Evaluation Methods:**

**Include a statement that explains how the achievement of the educational objective identified above will be assessed.**

**The procedures for determining students' grades should be specifically identified.**

Evaluation of the learning will be done via three classes of graded assignments.

First, we will use clickers in the course, which will be used to assess the students engagement in the material and the 'real time' understanding of the students.

We will also have several 'minor' assignments that will be used to analyze the student's understanding of a single concept within the course. General categories (and specific examples taken from them) include:

- Short responses to readings. For example, the students will be asked to reflect on the relative influence of Tufte versus Holmes in the way that data is visualized at present.
- Analyze and critique data visualizations. For example, the students will be given a visualization from the news, and asked to discuss the manner in which different design elements are used to manipulate the interpretation of the visualization.
- Generate data visualizations. For example, the students will identify a data set of interest to them, and then turn this data set into a clear visualization, using the elements of design.
- Gather and analyze data. For example, the students will identify a quantitative question of interest to them, and then either acquire the data themselves, or find a pre-existing source. The students will then provide measurements of central tendencies and range, as well as perform regressions of the data.
- Problems from textbook. This will include problems assigned directly from a book used for the readings and will develop basic skills in data analysis.

Finally, the course will have a capstone project, in which the students will be asked to combine all the learned elements of data handling and design. Specifically, they will be asked to identify a question that can be answered quantitatively, collect the data required to provide an explanation for their question, work up the data to extract this explanation, use their understanding of design to create a compelling data visualization that conveys their explanation, and provide critiques of their peer's projects. This project seeks to bring all of the learning objectives to bear on an integrative project.

The students' grades will come directly from these graded assignments, with the clicker questions accounting for 10%, the minor assignments for 50%, and the capstone project for 40%.

In addition to these graded assignments, the students will be given the opportunity to fill out surveys that allow them to discuss their impression of the course and the connection being made between data and design.

#### **Relationship/Linkage of Course to Other Courses:**

**This statement should relate the course to existing or proposed new courses. It should provide a rationale for the level of instruction, for any prerequisites that may be specified, or for the course's role as a prerequisite for other courses.**

This course is not seen as being a prerequisite for any other course. The only prerequisite will be entry into Math 22, as basic algebra skills will be required for the data analysis component of the course.

This course has some relation to existing courses in statistics, design, and introduction to science. However, this course is unique in the fact that it seeks to bring ideas from these courses together into a course focused on visual explanations of data.

The level of instruction for this course will be rather basic, in terms of the elements of data analysis and design. The course is not designed to be a capstone to any specific major. However, it is designed to introduce a wide audience to the intersection between data and design -- with a particular focus on understanding: (1) how they can use this knowledge to create compelling data visualization in support of their positions and (2) how others use elements of design to influence their own interpretation of data. In short, the course is designed to provide the students the tools and knowledge to critically navigate an increasingly data-driven world.

#### **Relationship of Course to Major, Option, Minor, or General Education:**

**This statement should explain how the course will contribute to the major, option, or minor and indicate how it may function as a service course for other departments.**

This course will not directly contribute to a major or minor option; however any department could choose to add this course to a list of approved courses. Instead, this course is intended to serve the general education of the students.

#### **A description of any special facilities:**

This course will require no special facilities.

#### **Frequency of Offering and Enrollment:**

This course will be offered once per year, in the fall semester. The first several years, the course will have a small enrollment (ca. 30 students). However, I will focus later efforts on accommodating larger enrollments. Much like reading, writing, and arithmetic, the ability to generate and consume data visualizations will continue to be ever more important for our students lives beyond the classroom. Thus, I would like to reach as many students as possible.

#### **Alignment with General Education Objectives**

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**✕ EFFECTIVE COMMUNICATION – the ability to exchange information and ideas in oral, written, and visual form in ways that allow for informed and persuasive discourse that builds trust and respect among those engaged in that exchange, and helps create environments where creative ideas and problem-solving flourish.**

**KEY LITERACIES** – the ability to identify, interpret, create, communicate and compute using materials in a variety of media and contexts. Literacy acquired in multiple areas, such as textual, quantitative, information/technology, health, intercultural, historical, aesthetic, linguistic (world languages), and scientific, enables individuals to achieve their goals, to develop their knowledge and potential, to lead healthy and productive lives, and to participate fully in their community and wider society.

**CRITICAL AND ANALYTICAL THINKING** – the habit of mind characterized by comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating a conclusion. It is the intellectually disciplined process of conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

**INTEGRATIVE THINKING** – the ability to synthesize knowledge across multiple domains, modes of inquiry, historical periods, and perspectives, as well as the ability to identify linkages between existing knowledge and new information. Individuals who engage in integrative thinking are able to transfer knowledge within and beyond their current contexts.

**CREATIVE THINKING** – the capacity to synthesize existing ideas, images, or expertise in original ways and the experience of performing, making, thinking, or acting in an imaginative way that may be characterized by innovation, divergent thinking, and intellectual risk taking.

**GLOBAL LEARNING** – the intellectually disciplined abilities to analyze similarities and differences among cultures; evaluate natural, physical, social, cultural, historical, and economic legacies and hierarchies; and engage as community members and leaders who will continue to deal with the intricacies of an ever-changing world. Individuals should acquire the ability to analyze power; identify and critique interdependent global, regional, and local cultures and systems; and evaluate the implications for people's lives.

**SOCIAL RESPONSIBILITY AND ETHICAL REASONING** – the ability to assess one's own values within the social context of problems, recognize ethical issues in a variety of settings, describe how different perspectives might be applied to ethical dilemmas, and consider the ramifications of alternative actions. Individuals should acquire the self-knowledge and leadership skills needed to play a role in creating and maintaining healthy, civil, safe, and thriving communities.

**What component(s) of the course will help students achieve the General Education Learning Objectives covered in the course? Provide evidence that students in the course have adequate opportunities to achieve the identified learning objectives.**

The general education objectives, and their connection to the activities in the course, are explicitly addressed in the syllabus that will be given to the students. I will describe them in brief here. The components of the course related to the general education are:

EFFECTIVE COMMUNICATION will be practiced through the creation of data visualizations, which are the means of communication of quantitative ideas and explanations. In addition, students will be providing critical analysis of their peers' visualizations, as part of prototyping and refining the visualizations. This critiquing also requires effective communication, in order to offer useful constructive criticism. Finally, the students will have several minor assignments specifically focused on critiquing professional visualizations with respect to these visualizations' ability to communicate ideas.

CRITICAL AND ANALYTICAL THINKING will be practiced through students' critical analysis of historical and current data visualizations as well as those of their peers. They will learn to analyze how plots can be manipulated in order to bias their interpretation. In addition, we will be examining how inferences are drawn from data, and the students will have practice in doing so from bookwork and with their own datasets. A key aspect of this work will be analyzing how confident one should be in these inferences.

INTEGRATIVE THINKING the course explicitly brings together understanding and knowledge from the arts (design) and sciences (scientific methods of data gathering and analysis). The students will routinely be asked to critique the pairing of these aspects in existing data visualizations and then will also be asked to combine them in data visualizations they will create.

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**How will students be assessed to determine their attainment of the Learning Objective(s) of General Education covered in this course? This assessment must be included as a portion of the student's overall performance in this course.**

Graded assignments will be used to assess the students' attainment of these learning objectives. While there will be several assignments, much of this can be accomplished using the capstone project. In this project, the students will be creating their own data visualizations drawing on their understanding of data handling and design (INTEGRATIVE THINKING). Along the way, they will be critiquing their peers' efforts towards identifying questions, gathering data to answer these questions, and prototyping of visualizations. These critiques naturally require CRITICAL AND ANALYTICAL THINKING, but also will require EFFECTIVE COMMUNICATION between peers. Finally, the students will present their visualizations orally and submit a written document defending their choice of visualization. These both will focus on EFFECTIVE COMMUNICATION.

In addition to the capstone course, there will be numerous (approximately 30) additional small assignments. The nature of these assignments, and how they relate to the general education learning objectives will be detailed in the syllabus, so that the students can understand the connection.

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## General Education Domain Criteria

General Education Designation: Inter-Domain

### GA Criteria

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Explain the methods of inquiry in arts fields and describe how the contributions of these fields complement inquiry in other areas

Demonstrate an expanded knowledge and comprehension of the role that the arts play in various aspects of human endeavor

Demonstrate competence in the creation of works of art and design

Demonstrate competence in analysis, critical thinking and interpretive reasoning through the exploration of creative works

**Identify and explain the aesthetic, historic, social, and cultural significance of important works of art and critically assess creative works, their own or others', through evaluative processes of analysis and interpretation**

**What components of the course will help students achieve the domain criteria selected above?**

The course will require the students to create at least five original data visualizations, which will allow them to DEMONSTRATE COMPETENCE IN THE CREATION OF WORKS OF ART AND DESIGN.

The students will be asked to critique the above data visualizations as well as historic and current professionally created visualizations. These critiques will DEMONSTRATE COMPETENCE IN ANALYSIS, CRITICAL THINKING AND INTERPRETIVE REASONING THROUGH EXPLORATION OF CREATIVE WORKS.

There will be a two week survey of the ancient and modern history of data visualizations. The students will also be exposed to modern rules of design. The students will be required to reference their knowledge of historical and current design in their critiques of data visualizations throughout the semester, requiring that they DEMONSTRATE AN EXPANDED KNOWLEDGE AND COMPREHENSION OF THE ROLE THAT THE ARTS PLAY IN VARIOUS ASPECTS OF HUMAN ENDEAVOR. They will also demonstrate this comprehension, as they use their understanding of design to answer questions that they themselves generate.

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## **GN Criteria**

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**Explain the methods of inquiry in the natural science fields and describe how the contributions of these fields complement inquiry in other areas**

**Construct evidence-based explanations of natural phenomena**

**Demonstrate informed understandings of scientific claims and their applications**

**Evaluate the quality of the data, methods, and inferences used to generate scientific knowledge**

**Identify societal or philosophical implications of discoveries in the natural sciences, as well as their potential to address contemporary problems**

**What components of the course will help students achieve the domain criteria selected above?**

Students will be generating their own questions and gathering data to answer them using standard population samplings or experimental design. They will be expected to defend their choices, which means they can EXPLAIN THE METHODS OF INQUIRY IN THE NATURAL SCIENCE FIELDS.

Students will analyze data sets and discuss how they can be used to generate knowledge and support scientific claims. Students will also generate and answer their own scientific questions. Together, these tasks will allow them to DEMONSTRATE INFORMED UNDERSTANDINGS OF SCIENTIFIC CLAIMS AND THEIR APPLICATIONS. The process of moving from data to data visualizations is a key aspect of extracting and communicating and applying such explanations in the sciences.

The process of moving from dataset to data visualization means that students must EVALUATE THE QUALITY OF THE DATA, METHODS, AND INFERENCES USED TO GENERATE SCIENTIFIC KNOWLEDGE. In particular, the course will focus on how inferences are drawn from data using correlations and regressions. Focus will also be on the limitations of these approaches and the confidence we can have in them, and how this is related to the quality of the data.

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## **Integrative Studies**

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**Explain how the intellectual frameworks And methodologies of the two Knowledge Domains will be explicitly addressed in the course and practiced by the students.**

For GA, the students will be introduced to the history of data visualizations. We will then use this understanding of history to develop the various design elements currently used in modern data visualizations. The students will then use this understanding to critique both historical and current data visualizations, as well as critique those of their peers. They will also use this knowledge to create effective data visualizations of their own.

For GN, the students will learn how to ask scientific questions and how to answer them with data. They will practice this process, and then analyze the acquired data, learning how to evaluate the quality of the data and how it was gathered. Finally, the students will use this understanding to extract explanations for natural phenomenon, which they will represent using data visualizations.

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**Demonstrate that each Of the two domains will receive approximately equal attention, providing evidence from course topics, assignments, or other course components, and that students will integrate material from both domains.**

I have created a detailed syllabus for this course. In this syllabus, I have identified, on a week-to-week basis which GA and GN elements are addressed by the week's activities. In addition, I provide a more granular analysis of treatment the knowledge domains, focusing on individual activities (in class and homework). From this analysis, I find that there are 110 instances of learning objectives being addressed, with roughly 31% instances of an activity involve GA objectives and roughly 35% instances of an activity involve GN objectives, with the remaining 34% instances involving GE objectives.

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**Briefly explain the staffing plan. Given that each Inter-Domain course is approved for two Knowledge Domains, it will be taught by an instructor (or instructional team) with appropriate expertise in both domains.**

This course could be taught by faculty in either GA or GN areas. For GA objectives, what is required is an understanding of the design elements that go into data visualizations, how these are used to create visual explanations, and the historical significance of these visualizations. For the GN objectives, what is needed is an understanding of how inquiry in the natural sciences works, as well as how one can gather and critically analyze data to produce reasonable explanations from the data.

Neither of these aspects are such that they could only be met by faculty in a single college. I am more familiar with faculty in the GN area, but within the College of Science, there are a large number of faculty that think critically about design of their figures and who are aware of at least the basics of the history behind data visualizations (e.g., Tufte, Holmes, Nightengale, etc.). Thus, I believe that they could read the resources listed in the syllabus and gain a more formal understanding of the elements of design and be

prepared to teach the course.

For faculty from a primarily GA department, an understanding of the the scientific method and the quantitative tools used to evaluate data also should not be an unreasonable expectation. Again, the resources provided in the syllabus are a good introduction to experimentation, population sampling, and means of inference that are the strong GN components of this course.

In short, there should be a large set of faculty that would have the skills needed to teach this course.

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**Describe the assessments that will be used to determine students' ability to apply integrative thinking.**

The assessments of integrative thinking will be accomplished by critical analysis of data visualizations as well as creation of original data visualizations.

Critical analysis of data visualizations will focus on both the scientific methods used to generate the data as well as the design elements used to express the data clearly. This analysis will require the students to understand the pairing of these knowledge domains when consuming the work of others.

Creation of a data visualization starts with asking a question and gathering data, and ends with the the final presentation of the visualization to their peers. This activity will require the students to pair understanding of data gathering and analysis with design of visual explanations -- integrating two knowledge domains.

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**Campuses That Have Offered ( ) Over The Past 4 Years**

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semester	AB	AL	BK	BR	BW	CR	DS	ER	FE	GA	GV	HB	HN	HY	LV	MA	NK	PC	SH	SL	UP	WB	WC	WS	XC	XP	XS	YK
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**UPLOADED DOCUMENTS FOLLOW:**



## **SC 103N: When Data Meets Design**

**MWF xx-xx Room xxx**

**3 Credits, GN/GA**

**Prof. Benjamin Lear (bul14@psu.edu)**

**Office hours: TR xx-xx, 333 Chemistry Building, or by appointment**

### **Course Description**

You will become an effective generator and consumer of the data visualizations that saturate public and professional discourse. You will examine the rules of design and how they can be used to construct compelling visualizations of data. You will use this knowledge to critique data visualizations from the media and your peers. You will also produce data visualizations of your own using datasets of your choice that are relevant to areas such as business, science, history, education, and politics. You will emerge from this course with an appreciation of how data visualizations influence your life as well as the skillset to craft persuasive visualizations to support issues of interest to you.

For the purposes of this course no prior knowledge is assumed in science, data handling, or design. We will build up the knowledge and vocabulary needed in order to pair these two domains and equip you with a lifelong tool for creating persuasive data-driven explanations.

### **Prerequisites and Recommended Preparation**

The only formal prerequisite for this course is placement into MATH 22. More generally you should be comfortable with performing simple algebra, reading tables, and interpreting simple graphs. Familiarity with microsoft excel or google sheets will be helpful.

### **Learning objectives**

Upon completing this course, you will be able to:

- 1: Explain the historical and current importance of data representation
- 2: Formulate questions that can be answered quantitatively.
- 3: Design and implement plans to gather data that answers quantitative questions.
- 4: Use rules of design to craft compelling data visualizations.
- 5: Critically analyze data visualizations.

There are three learning objectives that come from the GA knowledge domain.

**GA1:** Demonstrate competence in the creation of works of art and design.

**GA2:** Demonstrate competence in analysis, critical thinking and interpretive reasoning through the exploration of creative works.

**GA3:** Demonstrate an expanded knowledge and comprehension of the role that the arts play in various aspects of human endeavor.

There are three learning objectives that come from the GN knowledge domain.

**GN1:** Explain the methods of inquiry in the natural science fields and describe how the contributions of these fields complement inquiry in other areas.

**GN2:** Demonstrate informed understandings of scientific claims and their applications.

**GN3:** Evaluate the quality of the data, methods, and inferences used to generate scientific knowledge.

There are three general education learning objectives.

**GE1:** Effective communication.

**GE2:** Critical and analytical thinking.

**GE3:** Integrative thinking.

## Topics and Schedule

The above learning objectives will be addressed throughout the course. Below is a schedule of topics and assignments, as well as how they are connected to the general education learning objectives. As a note, I would encourage you to complete the reading before the start of the week it is assigned. That way, references to the reading in lecture will be most useful.

Week 1	
<b>Importance of design in data visualizations</b>	
We will examine a number of visualizations of data, and discuss what makes a visualization appealing or not. We will discuss how visual appeal help communicate the story of the plot more clearly.	
<b>Assignments</b>	
<b>1:</b> You will write one paragraph about the importance of visual appeal in data representations. Reflect on your impressions of the graphs presented in class.	
<b>2:</b> You will choose one example of a plot shown in class and explain in detail what you do and do not like about that visualization. See assignment for ideas on what to comment on.	
<b>Reading</b>	
<i>Universal Principles of Design:</i>	pg. 16, 20, 32
<i>The Basic Practice of Statistics:</i>	None
<i>Good Charts:</i>	Introduction (pg. 1-14)
<b>Connection to Learning Objectives (GA2, GA3, GE1, GE3)</b>	
<b>In class:</b> Examples of good and bad plots will be taken from current examples, showing the importance of visualizations in our society (GA3). The focus on how visual appeal works to engage an audience will address the importance of communication skills (GE1).	
<b>Assignments:</b> The reflection assignment will help the students better connect the importance of visual appeal with communication (GA3, GE1) while the written critique of these plots will begin the process of formally analyzing graphs and how their design impacts the interpretation of the data (GA2, GE3)	

## Week 2

### Early History of Data Visualizations

We will trace the development of data visualizations from prehistoric times up to the 1980s. Focus will be on how humanity moved from lists to tables to charts and how these charts evolved in order to better communicate ideas. We will cover the invention of the line chart, the bar chart, and the pie chart, among others.

### Assignments

- 1:** Choose one of the historic visual representations presented in class and critique it. Tell me what you like about that visualization and what you do not. Tell me what the underlying data seeks to explain. Suggest an improvement to it.
- 2:** *The Basic Practice of Statistics:* 1.4, 1.5, 1.6, 1.10, 2.4

### Reading

*Universal Principles of Design:* pg. 100, 184  
*The Basic Practice of Statistics:* Chapter 1 (pg. 3-20), Chapter 2 (pg. 80-91)  
*Good Charts:* Chapter 1 (pg. 17-32)

### Connection to Learning Objectives (GA1, GA2, GA3, GN1, GN2, GE2)

**In class:** We will be discussing significant historical works of art (GA3) and critically analyzing why and how they were made, as well as their relation to modern examples (GA1). In addition, we will discuss how these representations tie back to the methods of quantitative inquiry that are the basis of science (GN1). Finally, we will discuss how these graphs can be used as evidence-based explanations of natural phenomena (GN2).

**Assignments:** The critiquing of important visualizations will continue to advance the student's ability to critique works of design (GA3), while the introduction of worrying about the underlying data will start the students thinking about how these visualizations function as explanations in their own right (GN2). The problems from the book focus on the process of turning data into simple plots (GA1). This will function as a refresher for the creation of basic plots by hand, as well as the use of these representations as explanations (GN2).

## Week 3

### Modern History of Data Visualizations

We will cover the evolution of modern data visualizations from the 1980's onward, taking the debate between Edward Tufte and Nigel Holmes as the starting point. We will discuss the emergence of a modern aesthetic of data visualizations and then continue on to cover the explosion of visualization types that has come with the era of 'big data.' Focus will be on the push for ever greater clarity in data visualizations, and how these design ideas have taken over science.

### Assignments

- 1:** Write a 1 page reflection on the styles of Tufte and Holmes. In what ways do you agree with Tufte? In what ways do you agree with Holmes? Select an example of a modern data visualization (current year) and discuss if you think it takes more influence from Tufte or Holmes. In this discussion use language from your readings in *Universal Principles of Design*.
- 2:** *The Basic Practice of Statistics*: 1.27, 1.32, 1.35, 2.17, 2.20

### Reading

*Universal Principles of Design*: pg. 102, 106, 128, 137, 162, 172, 178, 224.  
*The Basic Practice of Statistics*: Chapter 1 (pg. 28-42), Chapter 2 (pg 97-102).  
*Good Charts*: Chapter 2 (pg. 34-49).

### Connection to Learning Objectives (GA2, GA3, GN1, GN3, GE1, GE2)

**In class:** The discussion of the different aesthetic preferences of Tufte and Holmes will serve as the first clear demonstration of how design choices influence the usability of data visualizations and their ability to persuade – highlighting the importance of design in effective communication (GE1). The use of historic examples will continue to give students an appreciation of the important works in data visualization (GA3). The connection to big data will function as the introduction to the methods of inquiry that are part of science (GN1). Finally, this will be the start of explicitly connecting the methods of modern science with the methods of design, starting the students in their integrative thinking (GE2).

**Assignments:** The reflection on the styles of Tufte and Holmes and their connection to modern works will build skills in the critical analysis of works of design (GA2) as well as the understanding the historical context of modern works (GA3). The problems from the book will function as a refresher as to the basics of working up data, extracting meaningful numbers from data, and understanding quality of data (GN3). These are the processes that underlie modern uses of data visualization.

## Week 4

### Asking (and answering) quantitative questions

We will address the sort of questions that can be answered using numbers. We will discuss when quantitative answers are appropriate and how the scientific method can be used to address questions. We will also discuss the various types of studies that exist that generate data, from historical surveys to experiments. We will generate a data set in class that can be analyzed. We will introduce a single simple plot to handle this data.

### Assignments

- 1:** You will work up the data generated in class. You will find the mean, median, mode, range, quantiles, and standard deviation of the data. You will then plot the data using a simple bar chart, on which you indicate the above extracted parameters. You will explain if your plot is more like that espoused by Tufte or Holmes, supporting this

position referencing concepts from *Universal Principles of Design*.

**2:** *The Basic Practice of Statistics*: 3.5, 3.8, 3.15, 3.33, 3.37

### Reading

*Universal Principles of Design*: pg. 52.

*The Basic Practice of Statistics*: Chapter 3 (pg. 166-200)

*Good Charts*: Chapter 3 (pg. 53- 72)

### Connection to Learning Objectives (GA1, GA3, GN1, GE3)

**In class:** Addressing how quantitative questions are generated and answered will give students a more firm understanding of the methods of inquiry in science (GN1). Generating data in class will show students how to be aware of how data is generated and collected (GN1). Together, this will also show the students how critical and analytical thinking come into play in the generation of data visualizations (GE3).

**Assignments:** Generating the plots for both assignments will begin the process of developing competence in the creation of works of design (GA1). Analysis of the plots in the context of Tufte and Holmes will tie what they are doing back to historical context of design (GA3). The problems from the book take a deeper look at how sampling of populations is accomplished and how experiments are designed. They are chosen to illustrate the methods of science (GN1) and how they can be used to gather quality data.

## Week 5

### How to gather and analyze data

We will discuss how people identify sources of data and break down data into manageable chunks. Focus will be on identifying a question that informs the gathering of data. We will talk about the importance of sample size. We will talk about how to find and use existing data sets online, or how to acquire data of your own in the world. We will also discuss the library resources present on campus for helping with this process.

### Assignments

- 1:** Identify 5 questions that you find interesting and which can be analyzed quantitatively. For each question provide a link to a source of data online for answering the question, or outline how you would gather data for this yourself. If you produce good questions, they might be used in your major project.
- 2:** For one of the questions you identified above, acquire a data set. Turn in this data set, together with a description of why you feel you can trust this data set, how you would analyze this data, what you would hope to learn, and the sorts of data visualizations that you think you could generate from them.

### Reading

*Universal Principles of Design*: pg. 194.

*The Basic Practice of Statistics:* Chapter 3 (pg. 204-205), Chapter 4 (pg. 214-218)  
*Good Charts:* Chapter 4 (pg. 74-104).

**Connection to Learning Objectives  
(GA1, GN1, GE2, GE3)**

**In class:** The discussion of the process of acquiring data and importance of sampling will involve discussion of how to identify quality of data (GN3). This will also naturally involve a discussion of the need for critical and analytical thinking when gathering data and analyzing it (GE3). The gathering of data is also a fundamental part of the methods of inquiry in the natural sciences (GN1).

**Assignments:** The generation of 5 quantitative questions will begin the process of scientific inquiry (GN1). The second assignment will involve critically evaluating the quality of the data (GN 3, GE3), while asking the students to propose visualizations of this data will continue to emphasize the process of creating effective visualizations for the data (GA1, GE2).

NOTE: It would be very good to take the first assignment seriously. This could really help in the development of your major project.

**Week 6**

**How to choose appropriate data visualizations**

We will survey the types of data visualizations commonly employed in the media and the sciences. The focus will be on how these visualizations are designed to represent different aspects of the underlying numbers. We will discuss what makes certain visualizations more appropriate for others, given the explanation of natural phenomena that one is attempting to convey.

**Assignments**

**1:** You will be given several sets of data. For each set, choose a style of data visualization you would choose to represent this data. You do not need to make the visualization, but you do need to explain why you think the visualization you chose is a good one.

**2:** Select one of the data visualizations you described in the previous assignment and generate this visualization. Supply a paragraph where you discuss if the visualization worked as well as you had imagined.

**Reading**

*Universal Principles of Design:* pg. 100, 194.  
*The Basic Practice of Statistics:* None.  
*Good Charts:* pg. 83.

**Connection to Learning Objectives  
(GA1, GN2, GE1, GE3)**

**In class:** The focus on selection of data visualization is a focus on effective communication of ideas (GE1). Each of the visualizations have different features and we will work to understand and analyze why different designs convey ideas better than others (GA2).

**Assignments:** The first assignment requires integration of understanding of data with the design of visualizations to communicate explanations (GA1, GN2, GE3). The second assignment asks the students to continue this process by creating a visualization (GA1, GN2).

## Week 7

### The Components of Data Visualizations

We will examine, in detail, the various elements of data visualizations. This includes (but not limited to) discussions of data markers, plot field, axes, tick marks, labels, legends, trend lines, and color.

#### Assignments

- 1:** Choose two different types of data visualizations. Provide 1 paragraph that identifies the elements they have in common. Provide a second paragraph that identifies the elements they do not share. In the final paragraph, discuss if any elements should be added or removed from each visualization.
- 2:** Return to your critique of the visualization from the first week. Take the paragraphs you wrote concerning what you did and did not like, and rewrite them using the language we developed this week.

#### Reading

*Universal Principles of Design:* pg. 48, 148.

*The Basic Practice of Statistics:* None.

*Good Charts:* Chapter 5 (pg. 110-132).

\*This week, there will be a handout outlining elements of charts in detail.

### Connection to Learning Objectives (GA2, GA3, GE1, GE2, GE3)

**In class:** We begin to pick apart the various elements of design for data visualizations to understand how they are constructed to aid in understanding data (GA2). Focus will be on the connection between design elements and data (GE2) and how to use this understanding to critically analyze data visualizations (GE3).

**Assignments:** The first assignment focuses down on understanding, in detail, the components that go into making a visualization and how they are connected to the different types of visualizations and designs (GA2). The second assignment tries to bring this into sharper focus, but returning to the connection between these elements and effective communication of data (GA2, GE1).

## Week 8

### Rules of Design for Data Visualization

We will introduce several very specific design concepts that come into play in the design of data visualizations. Focus will be on connecting these specific design concepts to the elements

of data visualizations described last week. We will also focus on how implementing these design concepts can aid in the effective communication of data – including the ability to accurately evaluate the quality of the underlying data.

### Assignments

- 1: Take a picture of something in your life that was designed. Discuss the design in that object using the language we developed this week.
- 2: Return to your critique of the visualization from the second week. Take the paragraphs you wrote concerning what you did and did not like, and rewrite them using the language we developed this week regarding design concepts. At the end, make suggestions for how one might improve the visualization using the elements of design and the components of data visualization.

### Reading

*Universal Principles of Design*: pg. 24, 31, 44, 50, 56, 96, 114, 116, 126, 176, 196, 208  
*The Basic Practice of Statistics*: None.  
*Good Charts*: Chapter 6 (pg. 134-152)

### Connection to Learning Objectives (GA2, GN3, GE1)

**In class:** Analysis of design elements, and how they are used to make compelling graphs (GA2). Discussion of how good design is important for allowing the reader to evaluate the quality of data (GN3). Discussion of how good design strengthens good communication (GE1).

**Assignments:** The first assignment will provide practice using the language of design in the analysis of crafted works (GA2). The second assignment connects analysis of the design of data visualizations (GA2) with good communication (GE1).

## Week 9

### Workshop: Applying the Rules of Design when Generating Data Visualizations

We will cement the prior two weeks topics, working on the creation of data visualizations from data using the design concepts on the elements of data visualizations. This week will be a mini workshop for the creation of visualizations. You will either choose one of the data sets you proposed in week 6, or work from a data set given to you. You will decide on an conclusion that can be drawn from the data. You will generate a visualization that seeks to communicate this conclusion and share share the visualization with your peers. Your peers will critique it for you. You will refine the visualization and have this critiqued. This will be repeated throughout the week.

### Assignments

- 1: You will generate a data visualization and refine it throughout the week. At the end of the week, you will turn in the final visualization, as well as the previous versions of



the visualization. You will describe how you decided the underlying data supported the story you were telling and how the visualization function as an explanation of how you understood the data. You will also supply written documentation discussing how you changed the plot with respect to implementation of design elements. Attach the critiques that were provided to you.

**2:** You will turn in the critiques you offered the other students in your class.

#### **Reading**

*Universal Principles of Design:* 40, 76, 118, 146, 160, 188.

*The Basic Practice of Statistics:* None.

*Good Charts:* Chapter 9 (pg. 209-222).

#### **Connection to Learning Objectives (GA1, GA2, GN2, GN3, GE1, GE2, GE3)**

**In class:** The in-class work is a guided workshop directly focused on accomplishing this week's assignments.

**Assignments:** The students will analyze datasets working to understand what conclusions are supported by the quality of the data (GN3). From this, the students will work to construct the evidence based explanations that they can (GN2). Working with this desired explanation, the students will then create a visualization that attempts to convey this (GA1). The students will then critique these visualizations analyzing the design aspects of them (GA2) and if the visualizations are supported by the data (GN3). Throughout this process, the students will be focusing on clarity in communication (GE1), critical analysis of the data and visualizations (GE3), and bringing integrating design and scientific reasoning (GE2).

NOTE: This is also a 'practice run' at the major project, though I don't think the students should be told this.

### **Week 10**

#### **How to lie with graphs (or know you are being lied to)**

We will examine the ways in which design elements of data visualizations can be manipulated (intentionally or not) in order to bias the interpretation of the data being presented.

#### **Assignments**

**1:** Write a 1-page essay addressing the following questions: Is there a right and a wrong way to represent data? Does data have meaning beyond that which we give it? If so, then where does this meaning come from? If not, then is one meaning preferable from another? Why? Conclude this writing by identifying a graph (that you find yourself or one from class) that you feel is misrepresenting data. Clearly state why you feel what is a misrepresentation of the data.

**2:** *The Basic Practice of Statistics:* 1.53, 1.54, 1.58, 1.60, 4.24, 4.41, 4.43

### Reading

*Universal Principles of Design*: pg. 108, 186  
*The Basic Practice of Statistics*: Chapter 1 (pg. 46-64), Chapter 4 (220-252).  
*Good Charts*: Chapter 7 (pg. 153-174)

### Connection to Learning Objectives (GA2, GN2, GN3, GE2, GE3)

**In class:** The discussion of how graphs can be designed to bias interpretation will necessarily require critical analysis of design (GA2) as well as an understanding of the quality of the underlying data (GN3). Combining these two requires integrative thinking (GE2) and demands critical analysis of the visualization and data before reaching a conclusion (GE3).

**Assignments:** The first assignment is designed to focus the student on the general ideas of truth and how they underlie our judgements on what we are seeing (GE3) and then connect this idea to the critical analysis of the design and underlying data of a plot (GA2, GN3). The problems from the book introduce the probabilistic models and theory that underlie interpretation of data and inference – which is the foundation of extracting explanations from the scientific method (GN2). We will build upon this understanding next week.

## Week 11

### Inferring conclusions from univariate data

We will examine the ways in which one can infer conclusions from data. Discussion will focus on hypothesis testing, confidence intervals, and other means by which we try to quantify our confidence in the conclusions we draw from data. We will also discuss how we represent these inferences visually.

### Assignments

**1:** You will work with a univariate data set you choose for yourself, or one of the data sets supplied to you. You will fit the data to a distribution. Given the result of the fit, you will discuss what the fit means and how confident you can be in the results of this fit.

**2:** *The Basic Practice of Statistics*: 6.1, 6.8, 6.26, 6.39, 6.52

### Reading

*Universal Principles of Design*: None.  
*The Basic Practice of Statistics*: Chapter 6 (298-348)  
*Good Charts*: Chapter 7 (pg. 153-174).

### Connection to Learning Objectives (GA1, GA2, GN1, GN2, GN3, GE3)

**In class:** Discussion of fitting and inferences will necessarily require an understanding of the quality of data (GN3). In many cases, it is the fit to data that produces an ‘explanation’ in science (GN2) and so we also will connect this idea of explanation back to our discussion of the methods of conducting science (GN1). We will discuss how to critically evaluate the results of these fits, so as to not accept them as ‘proof’ (GE3), will particular attention on how they

represented in data visualizations (GA1, GA2)

**Assignments:** The first and second assignments are designed to focus the students on evaluation of data (GN3), the process of using scientific methods to produce fits (GN1), and then the interpretation of these fits as possible explanations of the data (GN2). This is also a clear example of critical analysis (GN3). The first, assignment pairs these skills with the the creation of a work of design (GA1).

## Week 12

### Inferences in bivariate data

We discuss ways in which people represent inferences in data visualizations. Focus will be on trend lines, confidence intervals, and ways of depicting these ideas.

#### Assignments

**1:** You will work with a bivariate data set you choose for yourself, or one of the data sets supplied to you. You will choose two variables you think depend on one another and produce a fit to the data. Given the result of the fit, you will discuss what the fit means and how confident you can be in the results of this fit.

**2:** *The Basic Practice of Statistics:* 11.1, 11.5, 11.7, 11.9, 11.12

#### Reading

*Universal Principles of Design:* None.

*The Basic Practice of Statistics:* Chapter 11.

*Good Charts:* None.

### Connection to Learning Objectives (GA1, GA2, GN1, GN2, GN3, GE1, GE2, GE3)

**In class:** We will focus on how the presentation of trend lines can be designed in order to communicate different ideas and facilitate understanding of the data from the graph (GA1, GA2, GE1). We will also discuss how one can connect these design elements to the quality of data that supports them (GN3, GE2).

**Assignments:** The first assignment gives practice in extracting explanations from data (GN2) and creating representations of these explanations (GN1) in the form of trend lines. The second assignment delves deeper into how these inferences depend upon the quality of the data (GN3) and how the methods of inference fit within the scientific method (GN1), and gives you the tools for understanding how to critically evaluate these inferences (GE3).

## Week 13

### Workshopping Capstone Project: Part 1

During this week, you will be aiding each other in the selection of a quantitative question and data set to answer it. For this, you will be put into randomized groups, and you will both present your ideas and critique other ideas in your group. You will also share preliminary thoughts into the types of plots you envision making.

#### Assignments

- 1:** You will write an essay reflecting on how this class has changed the way you approach finding answers to questions. Are you more comfortable looking for data sources? Do you think that quantitative questions/answers are something you can generate for the rest of your life?
- 2:** Turn in the critiques you gave of the people in your group.

#### Reading

*Universal Principles of Design:* None.  
*The Basic Practice of Statistics:* None.  
*Good Charts:* None.

#### Connection to Learning Objectives (GA1, GN1, GN2, GN3, GE1, GE2, GE3)

**In class:** You will be implementing the steps of the scientific method (GN1), by identifying a question and designing the means to answer it. You will also be practicing critical analysis of the data and the question (GN3, GE3) and working to communicate your thoughts on other's ideas as well (GE1). The initial thoughts on types of plots will begin the process of creating a designed data visualization (GA1).

**Assignments:** The essay will help cement how applicable you feel these skills are in the rest of your life, and your ability to communicate answers to quantitative questions (GE1). The critiques you will provide also are practice of critical analysis of data (GN2, GE3).

## Week 14

### Workshopping Capstone Project: Part 2

In another randomly assigned group, you will work to design, prototype, and refine the visualizations of the data you selected last week. Focus will be on if the choice of plot that best presents the story you found in the data. You will also focus on the use of the elements of plots, in order to generate the most visually appealing plot you can.

#### Assignments

- 1:** Write an essay reflecting on your understanding of how plots are made and interpreted. Do you react to seeing plots of data in the news differently now? Do you think you will be confident making your own plots later in your career?

**2:** Turn in your critiques of the people in your group.

**Reading**

*Universal Principles of Design:* 198  
*The Basic Practice of Statistics:* None.  
*Good Charts:* Chapter 8 (pg. 177-207)

**Connection to Learning Objectives  
(GA1, GA2, GN2, GN3, GE1, GE2, GE3)**

**In class:** You will practice the critique of visual representations of data (GN2, GE3) using the knowledge of the language of design and the history of design (GA3). These critiques will focus on the explanation being offered by the data (GN2) and the quality of the data that is being used (GN3). Focus will be on clarity of communication (GE1) and integrating design and data (GE2). You will produce a work of design as a result (GA1).

**Assignments:** The essay will help cement how applicable you feel these skills are in the rest of your life, and your ability to communicate answers to quantitative questions (GE1). The critiques you will provide also are practice of critical analysis of data (GN2, GE3).

**Week 15**

**Presentations of Capstone Project to Class**

This week will be the culmination of the course. You will present your visualization to the class. You will also critique several presentations.

**Assignment**

**1:** Write a reflection on how your ability to critically assess data visualizations has changed over the course of the semester.

**2:** You will be asked to fill out a brief survey on how the course can be improved.

**Connection to Learning Objectives  
(GE1, GE2, GE3)**

**In class:** You will be practicing communicating the visualization you made, as well as critically analyzing the visualizations presented by your peers (GE1, GE2, GE3).

**Assignments:** The essay focuses on how your ability to critically evaluate information (GE3) has changed over the course of the semester.

**Assignments and Percentage of Grade**

This course consists of several small assignments, which focus on developing a single skill, as well as a capstone assignment that brings these skills together.

The smaller assignments will account for 50% of your grade. We will have 30 such assignments throughout the quarter (between 1 and 3 minor assignments each week). Each assignment will be worth 5 course points, and will belong to one of the following classes of assignments:

#	Description
1	<b>Short responses to readings.</b> You will be asked to write one paragraph to one page reflections on the readings assigned. Focus will be on identifying key historical moments in the development of data visualizations, or on the ways in which design elements appear in data visualizations.
2	<b>Analyze and critique data visualizations,</b> focusing on the design elements and treatment of data. At times you will ask to critique the general appearance. Other critiques will focus on how design is being used to bias interpretation of the data.
3	<b>Generate your own data visualizations.</b> You will either make entirely new visualizations, or will create alternative versions of existing visualizations. Focus will be on using and explaining design elements.
4	<b>Gather and analyze data.</b> You will focus on how to analyze the data and how to be aware of the quality of the data.
5	<b>Problems from textbook.</b> You will solve statistics problems from our textbook, in order to ensure the basic skills are in place for critically analyzing data and presenting meaningful analyzes of these data.

In addition to these minor assignments, there will be one capstone project in this course. This assignment brings together all aspects of the course, and you will be asked to create and present a data visualization of your own. More details for the exact format of the assignment will follow later in the course. The capstone assignment will be worth 40% of your grade. It can be broken up into 7 components with associated points:

#	Component	Points
1	Identify a question that can be answered using data.	5
2	Acquire data needed to answer your question. Analyze this data so that you are prepared to try your first plot.	5
3	Generation of data visualization. This will be an iterative process. You will likely make several attempts on the way to your final visualization. During this time, you will receive feedback from me and your peers.	20
4	Written presentation.	25
5	Oral presentation.	30

6	Critique of presentations. You will be required to provide critiques of your fellow peers' efforts. You will be given a form to fill out to help you in the critique.	15
7	Help in prototyping. You will be graded based on how active you were in the workshopping of the main projects of others.	20

The remaining 10% of your grade will come from answering clicker questions in class. Each day that you answer a majority of the clicker questions will be worth 1 point. You can earn a maximum of 30 points.

The total breakdown of course points is:

Minor assignments:	150 points
Major assignment:	120 points
Clicker responses:	30 points
<hr/>	
Total course points:	300 points

## Attendance and Participation Expectations

Attendance of any particular lecture is not required. However, we will be using clickers, and you must be present to earn clicker points.

## Examination Policy

There are no examinations for this course. There will also be no final examination.

## Grading Policies

Grades will be assigned based upon the percentage of total points you earn in the course. A possible grade distribution is as follows:

F	D	C	B	A
Below 60%	60-69%	70-79%	80-89%	90% and above

When assigning grades, percentages will not be rounded up or down. The percentage required for a particular letter grade must be met.

## Required Course Materials

There are three textbooks required for this course:

- *Universal Principles of Design*, by William Lidwell, Kritina Holden, and Jill Butler
- *The Basic Practice of Statistics*, by David Moore
- *Good Charts*, by Scott Berinato

In addition to textbooks, you will be required to have software capable of generating comma separated variable files (.csv). Microsoft excel, google sheets, and open office are all capable of doing this. You will also need software capable of generating the plots we use in this class. The recommendation is to use Veusz – a free, cross platform plotting software that can read from .csv files. However other options such as R, Matlab, Python, etc. are also acceptable. In general, excel, google sheets, and open office will not be sufficient to generate the plots required for this course.

## Additional Resources

In addition to the required textbooks, you might be interested in the following books:

- *The Visual Display of Quantitative Information*, by Edward Tufte. This is likely the most famous book on data visualization. It presents a history of data visualizations, and Tufte's ideas on what makes a good plot.
- *Visual Explanations*, by Edward Tufte. A follow up to his seminal book. Another book to be aware of.
- *Designer's Guide to Creating Charts and Diagrams*, by Nigel Holmes. A book by the leader of the competing school to Tufte's. This book contains many examples of plots that are not presented simply, as well as the rationale behind it. It is a good book for a different perspective.
- *Visualizing Data*, by William S. Cleveland. This is a book for true connoisseurs of working up data. Cleveland was a statistician presenting many of the specialized ways that statisticians present data.
- *Show Me the Numbers*, by Stephen Few. Another luminary in the field of data visualizations. A good book to be aware of, because it is well known in the field.
- *The Functional Art*, by Alberto Cairo. A book on data visualizations and infographics presented by a person that ran graphics departments for newspapers and magazines.
- *Everydata*, by xxx. Short chapters detailing real-world examples where the use of statistics gave new and valuable insight into problems from finance to football.
- *Naked Statistics*, by xxx. This is a conversational look at the world of statistics, its methods, and how they might apply to your life. .
- *Black Swan*, by Nassim Nicholas Taleb. Not a statistics book, per se, but a book that turns a critical eye to the assumptions that underlie modern statistics. In particular, it is a criticism of how pervasive normal distributions are in statistics.

Later in the course, you will want to work up data, and here are some websites that you might consider using to find data:

- The US Government: <https://www.usa.gov/statistics>
- Kaggle.com
- etc.

## Office Hours and Other Contact Information

If you have questions or concerns about the class, you should always feel free to send me an email (bul14@psu.edu). Typically, I check my email three time a day, and I will respond to an email by the end of the day.

In addition to email, you can also stop by office hours. This is a chance for us to meet face to face and for you to get more fluid feedback than can be accomplished over email. If you cannot make



the regular office hours, but still want to meet, you can make an individual appointment. To do so, please email me with three suggested times that work for you.

### **Academic Integrity Statement**

All Penn State Policies regarding ethics and honorable behavior apply to this course. Specifically for this course, unless otherwise explicitly stated on the homework, you are permitted to work in groups. Verbatim copying, however, is not permitted.

### **Disability Accommodation Statement**

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) Web site provides contact information for every Penn State campus: <http://equity.psu.edu/sdr/disability-coordinator>. For further information, please visit Student Disability Resources Web site: <http://equity.psu.edu/sdr>.

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: <http://equity.psu.edu/sdr/guidelines>. If the documentation supports your request for reasonable accommodations, your campus' disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. You must follow this process for every semester that you request accommodations.