PDAT 624G: Principles of Design in Data Visualization

Scott Thatcher, Fall 2021, Online Delivery

Contents

1 General Course Information

Instructor: Dr. Scott Thatcher

Office: Violette 2234

Phone: 660-785-4552 (A voice message will reach me relatively quickly.)

e-Mail: thatcher@truman.edu

Website: All course information is located on Blackboard

General Office Hours: MWF 1:30–3:20 p.m., T/Th 10:30–11:50 a.m.; and by appointment. *Thursday office hours are Zoom only.*

PDAT-Specific Office Hours: T 6:00–7:00 p.m. (Class Meeting), Th 5:30–6:30 p.m. (Office Hours). Check Blackboard for updates to my office hours and Zoom links.

Academic Success Coordinator: Ashleigh Harding, aharding@truman.edu, (660) 785-7403

1.1 Welcome

Welcome to PDAT 624! I'm excited to teach this class because design and data visualization are topics that are close to my heart. In this class, we'll cover the creation of static and interactive

data visualizations, as well as some of the basic vocabulary and principles of good design, with our without data. Along the way, we'll talk about the fact that data visualizations not only present data, but also tell a story, whether intended or not.

The first half of the class will cover basic tools and principles, while the second half of the class will cover specific applications, such as mapping, dashboard design tools, and specialized display techniques.

Along the way, I will be especially interested in your feedback. Which topics are confusing, which need more explanation/tutorial, which were satisfying, etc? Are there topics you want to make sure I cover?

1.2 Catalog Description

An introduction to the principles of good design, with application to data visualization. Students will learn about design principles in general through lecture, example and pen-and-paper practice. Students will then apply these principles in the context of data analysis and visual storytelling using appropriate software tools.

1.3 Prerequisites

Successful completion of PDAT 610: Introduction to Data Science and PDAT 611: Big Data Management. See Section 2.1 for further technology requirements.

1.4 Texts and Resources

There is no required textbook purchase for this course. Students may find the following resources helpful, and some will be used for required readings:

- Stephen Few, *Show Me the Numbers: Designing Tables and Graphs to Enlighten*, Second Edition ($20–$45). Analytics Press, 2012. ISBN-10: 0970601972.
- Pamela Sachant and Peggy Blood, *Introduction to Art: Design, Context, and Meaning*. https://open.umn.edu/opentextbooks/textbooks/introduction-to-art-design-context-and-meaning
- Roger Peng, *Exploratory Data Analysis* (free–$35). https://leanpub.com/exdata
- Garrett Grolemund and Hadley Wickham, *R for Data Science*. https://r4ds.had.co.nz/
- Rafael A. Irizarry, *Introduction to Data Science*. http://rafalab.dfci.harvard.edu/dsbook/
- Hadley Wickham, *ggplot2: Elegant Graphics for Data Analysis*. https://ggplot2-book.org/
- R Studio Cheat Sheets. https://rstudio.com/resources/cheatsheets/
- R Shiny Tutorials. https://shiny.rstudio.com/tutorial/
- Carson Sievert, *Interactive Web-Based Data Visualization with R, Plotly, and Shiny*. https://plotly-r.com/index.html

1.5 Course Outcomes

On successful completion of this class, students will:

- utilize visual thinking and ideation;
- critique and practice the linking between form (what is visually presented) and content (what the viewer experiences), and how these elements interact with context;
- identify and apply the elements of design (line, shape, color, scale, motion, etc.) in the display of data;
- apply the principles of design (composition, gestalt, theme and variation, etc.) in telling visual stories;
- identify and analyze the effect of historical factors, cultural milieu, political context, variously abled audience experiences, etc. and their impact on the way a message is received;
- practice moving between hand-rendered and digital formats, appreciating the strengths of each in the design process;
- develop competence in the creation of both static and dynamic multivariate information displays, ranging from individual graphs to interactive data dashboards, using tools such as
  - R and R packages such as `ggplot2` for the creation of static graphs,
  - other packages, such as `plotly` and `leaflet`, for creating interactive graphs,
  - R `shiny` for the creation of interactive data dashboards and applications, and
  - web-based visualization tools like plot.ly and tableau; and
- identify and describe the ethical dimension of data visualization design choices.

1.6 Credit Hours

For this eight-week class, the minimum investment of time by the average Truman student necessary to achieve the learning goals in this course is not less than two (50 minutes) hours of classroom instruction and a minimum of four hours of out of class student work each week per credit hour awarded, or at least the equivalent of six hours of laboratory work, internships, practica, and other academic work each week per credit hour awarded. This average time per week for an average student may have weekly variations.

2 Technology and Skill Requirements

2.1 Minimum Technology Requirements

In order to participate fully and effectively in an online course, students should have a reliable broadband connection (cable modem, DSL, satellite). Students should have a relatively new operating system (Linux, Windows 8 or higher; Mac OSX, etc.) and employ a compatible browser such as Firefox, Chrome or Safari. Courses use Blackboard Learn. For a list of compatible systems and browser types, visit Blackboard.

This course does use audio and video. Videos are close-captioned. To benefit from the audio you will need a computer equipped with speakers. This course also involves assignments requiring audio/video submissions. Thus, your computer will need to be equipped with a camera and microphone.

In order to complete assignments, you will need to use R and RStudio and be able to export R Markdown files as PDF. General familiarity with other standard office software is also assumed.

There may be assignments that ask you to do work on paper, scan the results, and upload the scan to Blackboard, perhaps using flatbed scanner, multi-function printer/scanner, or phone app. While I can't vouch for the fitness or security of any particular apps, Adobe does make an app called *Adobe Scan*, which should at least have the security/privacy profile of an app created by a large corporation, if you can live with that.

2.2 Minimum Technical Skills

While this isn't an exhaustive list, to be successful in this class, you should at least be able to

- access the Internet and be able to comfortably navigate websites using a web browser,
- maintain contact with me and the class through e-mail, Zoom, and Blackboard forums,
- apply your general coding skills and specific knowledge of R to write code and complete assignments,
- access outside resources that might provide data sets or coding documentation, etc., and
- scan and upload documents to Blackboard.

Many other skills are likely implied by the ones listed here. Ask if you have questions!

2.3 Technical Expectations for Completing Assignments

Assignments will be submitted through Blackboard, usually as PDF files and R Markdown code. Discussion assignments will completed using Blackboard forums and Zoom meetings.

2.4 Proctoring

There will be no proctoring necessary for assignments in this class.

3 Course Modules

Module 1: Elements

- Introduction to the elements of design: line, shape, value, color, scale, texture, space, motion, etc.
- Review and elaboration on elements of the "grammar of graphics" from PDAT 610 and 611.

Module 2: Principles

- Introduction to the principles of good design: composition, gestalt, theme and variation, etc.
- Introduction to principles of good data visualization.
- Accessibility issues in the use of color to convey information, and other issues related to context and intended audience.
- Critique of examples and pen-and-paper practice.

Module 3: Application of Design in Multivariate Data Visualization

- The possibilities of communicating mood and setting the stage for communication through the choice of color and other design elements.
- Critique of historical and modern examples of data storytelling, with attention to interpretation within context.
- Introduction to software tools in R (and beyond) to create more complex multivariate data displays.
- Introduction to color palettes, both in the abstract and through specific R implementations.
- Major Assignment 1: Redesign of a historical example of data-driven storytelling, including both a written critique and graphical product.

Modules 4 & 5: Interactive Data Visualization

- Elements and principles of design applied in an interactive setting.
- Introduction to software packages that create interactive displays, including R Shiny and Plotly.
- Major Assignment 2 introduced.

Module 6: More on Mapping and Geospatial Data

- Discussion of raster and vector-based mapping.
- R Packages such as `sf`, `leaflet` and `tmap` and `mapview`.
- Data operations on spatial data.

Module 7: Other topics in Data Visualization

- Specific visualization tools.
- Specific types of graphs. These topics may be instructor-driven or student-suggested.

Module 8: Final Project

Major Assignment 2: Creation of an interactive data visualization "product" using a contemporary real-world data set. The product will include the interactive visualization itself, a short video "telling their story," and a one or two-page written document describing statistical and design choices.

4 Assignments and Grading

4.1 Course Components

In addition to the two major assignments, each module will include at least one shorter assignment that reinforces the concepts and techniques taught in that section. Some assignments will involve coding, some may involve pen-and-pencil design, and some will involve discussion and/or critique of student work or common examples. Final course grades will be based on discussions, short assignment scores and major assignment grades, according to these percentages:

Assignment	Percent
First Major Assignment	25%
Second Major Assignment	25%
Assignment Critiques	10%
Shorter Assignments	30%
Discussions	10%

4.2 Grading

While a more lenient scale may be applied when assigning course grades, the table below shows minimum course grades that correspond to various point ranges. An overall course grade lower than a "C" is considered a failing grade, and no more than one course grade of "C" may be counted toward the master's degree. Students may retake a course to raise a grade not meeting minimum program requirements.

A	B	C
90%–100%	80%–89%	70%–79%

4.3 Discussion and Critique

The discussion assignment score will make up 10% of your total grade. I will not impose a strict word limit, but I will be looking for (1) evidence of substantial engagement with the material, and (2) evidence of regular interaction with me and with the rest of the class.

What does "substantial engagement" mean to me? Here are some guidelines:

- A good response to many discussion questions will draw the connection between abstract concepts and specific examples, specifically explaining how that example relates to the characteristics of that concept. Compare these two examples:
  - [Not so good] "I'd use regression to model expected sales because it's linear."
  - [Better] "Linear regression does well when the relationship between response variable and predictor variables can be modeled with a linear equation. Looking at the scatter plots of sales vs. advertising, and sales vs. consumer confidence, both appear to have a linear pattern. Therefore, regression seems appropriate in this situation."
- If a question asks you for a personal viewpoint, try to do some thinking, and share specifics (as you feel comfortable).
- Support opinions with evidence, or relate them back to concepts discussed in class.
- Try to avoid short "me too" responses to others' posts. Instead, ask yourself if you can paraphrase their important points and then add to them, or (respectfully) disagree with them.

We will have to live critique sessions during our evening meeting time related to the two major course assignments. Although you will be allowed to make them up in writing if you are forced to miss the live critique, I believe you'll get much more out of the live critique, and it will also be easier to complete in person than in writing.

4.4 Late/Redone Work

The assignments you turn in through Blackboard should represent your best work. I understand that sometimes something will go wrong with a particular assignment, and I do want to give you some flexibility to try again if necessary. On the other hand, I want to avoid a pattern of multiple submissions that incrementally inch toward a final product.

In an effort to find that balance, my rule for this class is that **students will be allowed a total of three late or redo submissions of graded assignments** during the semester. If you've submitted multiple versions of an assignment before I've graded it, I'll grade the most recent version. If there's been an obvious mistake, such as uploading the wrong document, that won't count against your allowed redos.

All that being said, remember that the best workflow is to

- start assignments with plenty of time,
- talk with me *before* you turn your assignments if you have questions or would like general advice as to whether you're on the right track,
- turn in a good assignment, and
- redo only if necessary.

4.5 Deadlines and Course Pacing

This course will feature relatively firm deadlines. Deadlines for the two major assignments will be set specifically so that we can all participate in critique at the same time. The smaller assign-

ments will be due weekly.

5 Course Policies and Expectations

5.1 Attendance

Students are strongly encouraged to join the weekly live Zoom meeting in order to better interact with me and other class members. Even if you don't feel "caught up," it is better to check in regularly. Past students have reported the sense of camaraderie to be a plus. Generally these sessions are not, however, strictly required.

There are two required meetings: our two critique sessions for the two major assignments. If an emergency causes you not to be able to attend these in person, you will be allowed to make up the critique in writing, but you must talk with me first. **Lack of attendance without contacting me will forfeit the points for that critique session.**

5.2 My Expectations of Students

My expectations of students include:

- Putting in time for this class commensurate with its accelerated pace: about 18 hours per week would not be an unreasonable ask for a three-credit, eight-week course. Of course individual students' experiences will vary.
- You are strongly encouraged to take advantage of posted virtual office hours. If you cannot meet during the posted hours, additional appointments can be arranged. I will create a Zoom meeting space for virtual office hours and post this information in Announcements on Blackboard. Individuals needing to consult privately may do so by phone or arrange a time to conference separately.
- Ask questions, and stay in contact with me, especially if you run into roadblocks or "real life" emergencies! I'll help as much as I can, but there's not much I can do if you disappear completely!
- Engage in both the coding and discussion aspects of the class. Discussion is difficult in online classes, but I've found that it can be good with a population of students who are looking to get a positive experience out of it.
- Engage in discussions with me and other students politely and respectfully.
- Know important class dates and keep track of assignments.

5.3 What Students Should Expect of Me as Their Instructor

You can expect me, as the instructor, to

- Respond to e-mail and other communication within 24–48 hours.
- Regularly engage with discussions posted on Blackboard, although I may leave space for students to comment first.

- Grade submitted assignments within 48 hours, unless there are a rush of submissions. Notify you if there's a slowdown.
- Post regular announcements about the class, especially if there are changes or updates to assignments or schedules.
- In case of unforeseen events that force me to step away from the class for more than 48 hours, notify you as soon as possible, and provide for alternate points of contact if at all possible.

5.4 Response Time and Feedback

As stated above, I will strive to respond to communication within 24–48 hours and grade most assignments within 48 hours. Communication that I receive over a weekend or holiday may be answered on the next "business" day, but I'll often answer over the weekend.

5.5 Student Interaction

You've enrolled in a program that features a human on the other end of the internet connection! I strongly encourage you to keep in contact with me, and strive to keep up with the material. The discussion forums are a good place to ask and answer questions, and it's often helpful to be asking questions when other students are also looking at the same material.

We will have weekly live Zoom meetings, which are not required, but they're a quick and easy way to make sure you feel caught up and connected to what's going on in class. I'll also have regular Zoom office hours posted on Blackboard and by appointment.

5.6 Netiquette and Civil Dialog

Etiquette for the net is important in an online or blended online course because of the significant amount of communication taking place in an environment that is not face-to-face (though much of what we discuss here has its applicability in face-to-face settings as well).

A few good rules to keep in mind include:

- Avoid communication strategies that could easily lead to misunderstanding. Avoid using slang and jargon. Avoid jokes and sarcasm. Don't use ALL CAPS or lots of exclamation points!!! These can seem like yelling or incorrectly convey the intensity of emotion.
- Write to communicate with clarity. Avoid using emojis, texting abbreviations, and technical terms that do not apply to the course. Include a clear subject line in email and discussion board communications. Write in a manner that conveys professionalism, as if you were writing a formal letter or a research paper. Make responses in discussion boards substantive by avoiding short responses that do not add to the conversation (e.g. "I agree!" "Good point.")
- Be considerate of your legal and ethical obligations. Be sure to avoid posting content that would constitute plagiarism or violate copyright law. This would include unattributed quotations, posting copies of print articles, sharing photos you do not have permission to share, etc. Do not engage in behavior that would be considered discriminatory or

harassing. There may be concrete repercussions for behavior that would violate the Academic Honesty or Discrimination policies articulated elsewhere in this syllabus.

5.7 Academic Honesty

The General Catalog states:

> Students are expected to do their own academic work. Any student involved in cheating on a paper, an examination or in any other form of academic dishonesty is subject to disciplinary action, including suspension or expulsion from the class, the student's academic program, or the University.
>
> Serious cases of academic dishonesty are reported by the faculty member to his or her Department Chair and to his or her Dean, who may take additional disciplinary action against the dishonest student, including suspension or expulsion from classes in the School. The Dean reports the dishonesty to the Vice President for Academic Affairs, who may also report it to the Vice President for Student Affairs. The Dean may also report the dishonesty to the School in which the dishonest student is enrolled as a major; the Dean of this School may suspend or expel the student from the academic program in the major. The Dean of Students may also suspend or expel the student from the University as outlined in the Student Conduct Code for incidents of academic dishonesty.

More information can be found in

- the General Catalog at http://catalog.truman.edu/, and
- the Student Conduct Code Section 8.050.1 at https://www.truman.edu/wp-content/uploads/2018/08/CHAPTER-8-REVISED-August-4-2018.pdf.

In this class, we'll be writing a lot of code. I expect the code you write to be your own work—after all, the purpose of this class is to help you practice your skills, and you won't get that practice if you simply copy code from someone else. I assume that developing your knowledge and skills is an important reason you're in this program!

Having said that, here is a non-exhaustive list of standards concerning common situations and questions that have come up in the past:

- **Study Groups:** I encourage you to exchange ideas through our Blackboard discussion forums or though study groups you might form with other class members. However, after you discuss an assignment, you should disengage from the group and make sure to write up your work on your own. This is the only way to make sure that you understand what's going on!
- **Credit Where Credit is Due:** If you do work with a study group, give credit to the members of the group in your assignment write-up.
- **Outside Sources:** Especially when writing code, you don't live in a vacuum. It's natural to look online (through Google or Stack Exchange, for example) for solutions to coding problems. When you do this, or access other outside sources (living or non-living), you should also give credit. A link to the site where you found the code snippet you adapted, or an

acknowledgment of the human who helped you, etc. Not only is this ethical, but it's also extremely valuable when you need to see that solution again, and perhaps the search result no longer appears at the top of a Google search. This practice has saved me time on multiple occasions

- **Fully Worked-Out Examples:** It's generally **not** OK, in the context of this class, to Google something like "regression analysis of the mtcars data set" in order to find fully-fleshed-out code, graphs, explanation, etc., for a homework problem that I've asked you to do. Not only are you cheating yourself of the experience of learning on your own, but much of the stuff that people post online is of questionable value, at best. There are a lot of bloggers who *think* they understand data science, but fewer who actually do!

6 Important University Policies and Procedures

6.1 Substantive Interaction

Truman policy and federal regulations require that students demonstrate that they are academically engaged in the courses they take. You must meet this requirement within the first calendar week of the block, beginning at 12:00 a.m. on Monday, October 17 and ending at 11:59 p.m. on Saturday, October 22. Failure to do so, or to provide an explanation of an extenuating circumstance by that date and time will result in your removal from the course. Under certain circumstances, removal could impact your scholarship eligibility or financial aid.

This policy is not intended to be punitive, but rather intended to protect students who never intended to remain enrolled in the course from surprise tuition charges.

For the purposes of this class, establishing academic engagement requires, at a minimum, completing any of the on-line assignments from Module 1 or posting a introductory post in the "Bulldog Cafe" section of the Discussion forum.

6.2 Important Dates

- **Start Date:** Monday, October 17, 2022.
- **End Date:** Friday, December 16, 2022.
- **Last Drop Date:** Friday, December 9.
- **Withdrawal Date:** Friday, December 9.

See the Registrar's Office (registrar.truman.edu) for more detailed calendars.

6.3 Disabilities, Emergencies, Discrimination and Title IX

Standard University-wide policies, resources, and procedures can be found at the following site:

https://wp-internal.truman.edu/provost/syllabus-resources-for-students/

This site includes information related to accommodations for disabilities, emergency procedures, and discrimination and Title IX concerns.

6.4 COVID Precautions

Consistent with guidance for higher education institutions from the Centers for Disease Control and to help us reduce the possible spread of COVID-19, requirements to wear a mask will follow University-wide policy for all in-person course meetings. When a mask mandate is in place, you will be expected abide by mandate guidelines and to keep the covering over your mouth and nose. During office hours, you will be required to wear a face covering. In the event you are without a face covering, you will be asked leave until you are able to obtain one and return. In the absence of a campus-wide mask mandate, individuals who have not been fully vaccinated or have underlying medical conditions that increase their risk for infection are strongly encouraged to wear a mask on campus.

6.5 FERPA

Education records are protected by the Family Education Right to Privacy Act (FERPA).More information can be found at: http://www.truman.edu/registrar/ferpa/. Course grades, assignments, advising records, etc. cannot be released to third parties without your permission. There are, however, several exceptions about which you should be aware. For example, education records can be disclosed to employees or offices at Truman who have an "educational need to know." These employees and offices may include your academic advisor, the Institutional Compliance Officer, the Registrar's Office, or Student Affairs depending on the type of information.

6.6 Disruptive behavior

Disruptive behavior is defined as

> Behavior that persistently or flagrantly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. (Washington State University)

If a student is exhibiting disruptive behavior, they may be asked to leave class until a solution for the disruptive behavior is found. They may also be reported to the Office of Citizenship and Community Standards.

7 Important Contacts

Various offices that provide services to online students are identified at the One Stop Services page (online.truman.edu). Should you need to consult with administrators that oversee this department and course, here is the contact information for those individuals:

- **PDAT Program Director:** Hyun-Joo Kim
  hjkim@truman.edu
  660-785-4693
  Violette Hall 2248.
- **Statistics Department Chair:** Scott Alberts
  salberts@truman.edu

660-785-7649
Violette Hall 2132.

- **Dean, School of Science and Mathematics:** Timothy Walston
  tdwalston@truman.edu
  660-785-4248
  Magruder Hall 2004.

Hopefully your experience with this class is positive. When and if you feel a complaint about this or another course is required, however, the procedure for lodging a complaint can be found on the University's Report a Complaint page (truman.edu).

Students taking an online course from outside of the state of Missouri should follow the complaint procedure offered here (truman.edu). Students are always asked to address their complaint to the professor of the course first when possible, then take their concerns to the Department Chair if the matter cannot be resolved with the faculty member.

8 Student Support

The University provides a range of both academic and student support services to ensure your success. These offices can advise you on learning strategies, point you toward valuable services, and help you troubleshoot technical problems as they arise.

8.1 Center for Academic Excellence

The Center for Academic Excellence (truman.edu) provides advising services for students in their first year for most departments, as well as tutoring services. The Center is located in Kirk Building 112 and it may be reached at 660-785-7403.

8.2 Counseling Services

Counseling Services (truman.edu) are available on campus at McKinney Center. Appointments may be scheduled by calling (660) 785-4014. An after-hours crisis line is also available at 660-665-5621.

8.3 IT Help Desk

The IT Service Center (truman.edu) has combined the IT Call Center, Help Desk and Telephone Services into a one-stop location to serve you. You will find the following services and more when you stop by Pickler Library 109 or call 660-785-4544. You may submit a customer support ticket at this web address. (truman.edu)

8.4 Writing Center

I encourage you to use the University's Writing Center (truman.edu) for your writing projects. It is not a proofreading service. The writing consultants will read your work and give you feedback, letting you know what is working well (and why) and what might not be working so well (and why). They can help you understand and better your writing craft. They can also do brainstorming

if you're having a hard time getting started. And they have an online scheduler, so making an appointment is easy.

8.5 Student Survey of Instruction

You will be asked to complete a survey regarding my instruction in this course at the end of the term. The survey is anonymous and I will not see the results until after grades have been completed. It is very important that I receive this feedback as it helps me to continuously improve this class. It also helps the University make decisions about our overall curriculum. Please be sure to participate in this survey opportunity.