Stanford GRADUATE SCHOOL OF EDUCATION

STEP Stanford Teacher Education Program

EDUC 261E: Curriculum and Instruction Elective in Data Science

Teaching Data Science in Secondary School

Spring 2022
Class Meetings: CERAS 108

Instructor: Victor R. Lee, Ph.D. {he/him}
Email: vrlee@stanford.edu
Victor's Office Hours: By Appointment

Overview

There is an abundance of data being continually produced and it is transforming practice in academic disciplines and professional life. A whole interdisciplinary field of 'data science' has emerged and spawned training programs and new types of jobs. Whether we are fully aware of it or not, data and data science permeate many aspects of our daily lives. The ability to work with, understand, and use data has already become an essential life skill and a requirement for an ever-expanding range of jobs and careers. It is becoming imperative that both the current and next generation of educators be aware of these changes and prepared for teaching students to thoughtfully engage with data.

While some students currently learn to work with data in statistics, math, and science courses, we are going to see much more integration of data and data science in the K-12 curriculum. We are also beginning to see, and should continue to expect, the rise of dedicated courses, units, and modules labeled as 'data science' for secondary students. A number of questions abound with respect to what those will entail. This course will identify and examine some of those questions. Further, it will prepare teacher candidates to integrate instruction with data and data science into their teaching by modifying or designing their own lessons.

Students in this course are primarily pre-service teachers in the Stanford Teacher Education Program (STEP). Therefore, the primary emphasis of this course is on tools and techniques for teaching secondary grade level data science and data science integration.

For those interested in academic research on data science education, consider enrolling in *EDUC 431: Thinking and Learning with Data*.

For those interested in learning how to use the computational tools and principles used in data science, consider enrolling in *EDUC 423A* and *423B: Introduction to Data Science I* and *II*.

Course Objectives

By the end of the course, students will be able to:

- Recognize and respond to common challenges students have when reasoning with data
- Articulate some major topics that would be addressed in related to Data or Data Science in secondary education
- Name, compare, and evaluate tools, platforms, environments, and curricula that are used in data science and data science education
- Design data-intensive lessons and instruction for a target learner population

Course Expectations and Structure

Attendance

Students are expected to attend all class meetings as scheduled unless there is a legitimate and excusable reason for missing class that day. If you know you will be absent, please inform the instructor as soon as possible. Classes will include discussions and learning activities that build off of previous weeks, so consistent attendance is important.

Readings and Other Media

Readings and related class media are listed in the Class Schedule below. All assigned readings and media designated as "Required" should be completed and/or reviewed prior to the class meeting for each week. This includes readings and media that should be done prior to the first class meeting (i.e., Week 1 readings should be done before the first class). Some readings are marked as *excerpted, meaning you should freely skim sections but concentrate on the indicated pages.Readings and media marked as "Optional" do not need to be read or viewed in preparation of the course, but they are recommended for those interested in the topic. "Further Readings:" provides some pointers to excellent work that you may wish to examine if you are very interested in this topic. Readings from these authors are more likely to appear in EDUC 431.

The instructor reserves the right to change reading assignments as the course progresses. It's possible some readings may be dropped or others may be added. You will have at least a week's notice of any changes to the reading list. When possible (keeping in mind copyright restrictions and availability of electronic versions), electronic copies of course readings will be posted in the course's Canvas site. Brevity, approachability, and 'free to students' are guiding principles in the selection of course readings and media.

Assignments and Course Grading

All assignments except for class participation should be submitted through Canvas. Assignments should be ready to share prior to the start of class for the week that it is due as we will share and compare our work with one another during class. However, you will have until the end of day (11:59 PM, Pacific time) to submit your assignment documents through Canvas.

Class Participation (20%)

Each class session, everyone is expected to actively participate in discussion and activities. Our goal is to develop a learning community that is building shared knowledge and understandings. Bring readings and notes to class to support your discussion.

Dear Data (20%)

The goal of this assignment is to get you involved in collecting and representing data so that you think about the pervasiveness of what can be turned into data. You are to strive to consistently keep track of some behavior or activity and then invent a representational notation that can visually show 10 days worth of data. An alternative to consider is to take inventory of something in your life that can be represented graphically. The representation itself should not emphasize words or numbers, but there should be some separate text to help a viewer decode what you made. Refer to the Dear Data readings and examples for ideas. More information is in the Dear Data Assignment description.

Interview Assignment (30%)

You are to pick a data science topic, visualization, or tool and conduct an interview with one or more students in the target age range that you expect to teach in the future. Likely, this will be a student in the classroom of your cooperating teacher. However, you can opt to engage with a someone else. This interview should last no more than 30 minutes and emphasize getting the student to think out loud about the topic. You should design a task for the student to think through, such as making inferences from a data representation, explaining their ideas of how a data process works to produce a given visualization, how businesses collect and use personal data, or the ethics of data, etc. You will submit a copy of your interview protocol, notes taken from the interview, and a reflection document summarizing what you had gleaned from the interview that informs your instruction. Topics can vary and include matters such as: the nature and presence of data, statistical ideas related to measures of center or inference, data visualization techniques, how a machine learning procedure works, correlation and causation, etc.

Data-intensive Lesson (30%)

Prepare a lesson spanning 1-5 days that clearly identifies one or more data-related learning objectives, articulates the activities that would be completed, and provides supplemental materials (slides, worksheets, web forms, data sets, etc). The objectives can come from standards documents or be an objective you articulate and wish to target. You should also include an assessment strategy for how determining if your lesson objectives had been met, which can take the form of portfolio requirements, a rubric, test-like questions, indicators from the student. What is important in the preparation of this lesson is that it be in a form that you would actually (and hopefully!) use.

Late Work and Incomplete Work

It is expected that all work is submitted on time when it is due. A digital version of your

assignments should be submitted through Canvas. Assignments should be submitted prior to the start of class of a given week unless otherwise noted in Canvas.

COVID-19 Exceptions

If you or someone close to you is infected with COVID-19, the priority should be health and safety. This also applies to mental health and general wellness. Exceptions to any of the above policies will be made should a COVID-19 situation arises.

Students with Documented Disabilities

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: http://studentaffairs.stanford.edu/oae).

Academic Integrity and Honor Code

The Honor Code is the university's statement on academic integrity written by students in 1921. It articulates university expectations of students and faculty in establishing and maintaining the highest standards in academic work. The Honor Code is an undertaking of the students, individually and collectively that they will not give or receive aid in examinations; that they will not give or receive unpermitted aid in class work, in the preparation of reports, or in any other work that is to be used by the instructor as the basis of grading. For more information, see https://communitystandards.stanford.edu/

Plagiarism is a violation of the Honor Code.

> "For purposes of the Stanford University Honor Code, plagiarism is defined as the use, without giving reasonable and appropriate credit to or acknowledging the author or source, of another person's original work, whether such work is made up of code, formulas, ideas, language, research, strategies, writing or other form(s). Moreover, verbatim text from another source must always be put in (or within) quotation marks."

If you are in doubt about what constitutes plagiarism in the context of a particular assignment, talk with the instructor.

Honor code violations will be reported to university administration.

Syllabus Re-use

The instructor and designer of this course (Victor Lee, vrlee@stanford.edu) is happy to support re-use of contents of this syllabus by others designing and teaching similar courses, which can range from reading selections, focal topics, or specific activities. If you do use portions of this syllabus or course or adapt ideas from it, the instructor would greatly appreciate a brief

acknowledgment statement and would welcome notification via email. Similarly, if you have any enhancements you can share that improve the learning experience, the instructor would appreciate hearing about those too.

Thanks to the Stanford Teacher Education Program, colleagues, and students who encouraged this course to come into existence.

Schedule

Week & Topic	Readings and Media	Assignments
Week 1 Introduction	**Required** Erickson, T. (2017, February 21). *Smelling like data science*. A best case scenario. https://bestcase.wordpress.com/2017/02/21/smelling-like-data-science/ Lupi, G., & Posavec, S. (2016). *Dear data*. Chronicle Books. (Selected Excerpts) Penguin Books UK. (2016, August 31). *Get To Know Someone Through Their Data | Dear Data* [Video]. YouTube. https://www.youtube.com/watch?v=mMJ2wrB8b2Q **Optional** Finzer, W. (2013). The data science education dilemma. *Technology Innovations in Statistics Education*, *7*(2). **Further Reading**: Writings related to the Quantified Self movement by Lee, Nafus, and Lupton. LA Times Op-Ed by Leavitt and Boaler.	
Week 2 What is 'Professional' Data Science?	**Required** Mitchell, M. (2019). *Artificial intelligence: A guide for thinking humans*. Penguin UK. Chapter 2: Neural Networks and the Ascent of Machine Learning (pp. 35-42) Geitgey, A. (2014, May 5). *Machine learning is fun!* Medium. https://medium.com/@ageitgey/machine-learning-is-fun-80ea3ec3c471 **Pick one (Required):** *Deep learning* Geitgey, A. (2016, June 13). *Machine learning is fun! Part 3: Deep learning and convolutional neural networks.* Medium. https://medium.com/@ageitgey/machine-learning-is-fun-part-3-deep-learning-and-convolutional-neural-networks-f40359318721#.o6srqap2e *Speech Recognition* Geitgey, A. (2016, December 23). *Machine learning is fun! Part 6: How to do speech recognition with deep learning.* Medium.	

	https://medium.com/@ageitgey/machine-learning-is-fun-part-6-how-to-do-speech-recognition-with-deep-learning-28293c162f7a *Facial Recognition* Geitgey, A. (2016, July 24). *Machine learning is fun! Part 4: Modern face recognition with deep learning.* Medium. https://medium.com/@ageitgey/machine-learning-is-fun-part-4-modern-face-recognition-with-deep-learning-c3cffc121d78 **Optional** Klosowski, T. (2020, July 15). *Facial recognition is everywhere. Here's what we can do about it.* The New York Times. https://www.nytimes.com/wirecutter/blog/how-facial-recognition-works/ **Further Reading:** Books by Hadley Wickham, *Data Science in Education Using R* by Estrellado et al., *Data Feminism* by D'Ignazio & Klein	
Week 3 Bias, Equity, & Privacy	**Required** O'Neil, C. (2016). *Weapons of math destruction: How big data increases inequality and threatens democracy*. Crown. Chapter 5: Civilian Casualties Justice in the Age of Big Data (pp. 84-104) TED. (2017, March 29). *How I'm fighting bias in algorithms | Joy Buolamwini* [Video]. YouTube. https://www.youtube.com/watch?v=UG_X_7g63rY&t=4s Browse this website: International Computer Science Institute. (2014, May). *Teaching Privacy.* https://teachingprivacy.org **Optional:** Hautea, S., Dasgupta, S., & Hill, B. M. (2017). *Youth Perspectives on Critical Data Literacies*. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, Denver, Colorado, USA. https://doi.org/10.1145/3025453.3025823 boyd, d., & Crawford, K. (2012). Critical questions for big data. *Information, Communication & Society, 15*(5), 662-679. doi:10.1080/1369118X.2012.678878 Coded Bias Documentary: https://searchworks.stanford.edu/view/13782783	**Dear Data Assignment Due**

	Further reading: *Algorithms of Oppression* by Safiya Noble, writings from Ruha Benjamin, and the full *Weapons of Math Destruction* book, *Data Feminism* by D'Ignazio & Klein	
Week 4 Data Platforms	**Required** Nieves, B. (2020). DataClassroom. *The American Biology Teacher, 82*(7), 509-509. doi:10.1525/abt.2020.82.7.509 Reiten, L., & Strachota, S. (2016). Promoting statistical literacy through Tuva. *The Mathematics Teacher MT, 110*(3), 228. doi:10.5951/mathteacher.110.3.0228 Rosenberg, J., Edwards, A., & Chen, B. (2020). Getting messy with data: Tools and strategies to help students analyze and interpret complex data sources. *The Science Teacher, 87*(5), 30-34. **Further reading:** See Tableau, Social Explorer, and GapMinder, as well as *New York Times* What's Going on in this Graph?	
Week 5 Students' Ideas About Data	**Required** Bowler, L., Acker, A., Jeng, W., & Chi, Y. (2017). "It lives all around us": Aspects of data literacy in teen's lives. *Proceedings of the Association for Information Science and Technology, 54*(1), 27-35. doi:10.1002/pra2.2017.14505401004 Gebre, E. H. (2018). Young adults' understanding and use of data: Insights for fostering secondary school students' data literacy. *Canadian Journal of Science, Mathematics and Technology Education*, *18*(4), 330-341. **Further reading:** See work by Sonia Livingstone, Common Sense Media	
Week 6 Reasoning with Data	**Required** Konold, C., Higgins, T., Russell, S. J., & Khalil, K. (2015). Data seen through different lenses. *Educational Studies in Mathematics, 88*(3). (pp. 308-321, *excerpted) Lee, V. R., & Wilkerson, M. (2018). *Data use by middle and secondary students in the digital age: A status report and future prospects*. (pp. 1-8, *excerpted)	**Student Interview Assignment Due**

	Geckoboard. *Data fallacies.* https://www.geckoboard.com/best-practice/statistical-fallacies/ **Optional:** Erickson, T., Wilkerson, M., Finzer, W., & Reichsman, F. (2019). Data Moves. *Technology Innovations in Statistics Education, 12*(1). Retrieved from https://escholarship.org/uc/item/0mg8m7g6 **Further reading:** See statistics education and data modeling research including but not limited to Ben-Zvi, Lehrer & Schauble, Petrosino, Konold, Rubin, Makar, Wilkerson, GAISE II, consider taking EDUC 431 for more	
Week 7 Data in Social Studies and Humanities	**Required** Craig, K. (2017). Analog tools in digital history classrooms: An activity-theory case study of learning opportunities in digital humanities. *International Journal for the Scholarship of Teaching and Learning, 11*(1). (pp. 4-10, *excerpted) Handelman, S. (2020, June 2). W.E.B. Du Bois' Visionary Infographics. Retrieved from https://drawingmatter.org/w-e-b-du-bois-visionary-infographics/ Radinsky, J., Hospelhorn, E., Melendez, J. W., Riel, J., & Washington, S. (2014). Teaching American migrations with GIS census webmaps: A modified "backwards design" approach in middle-school and college classrooms. *The Journal of Social Studies Research, 38*(3), 143-158. (read pp. 146-154, *excerpted) Shreiner, T. L. (2019). Students' use of data visualizations in historical reasoning: A think-aloud investigation with elementary, middle, and high school students. *The Journal of Social Studies Research*, *43*(4), 389-404. (read pp.392-400, *excerpted) **Further Reading:** *W. E. B. Du Bois's Data Portraits: Visualizing Black America* from the W.E.B. Du Bois Center at the University of Massachusetts, *Data Feminism* by D'Ignazio & Klein	
Week 8 Data in Art and Science	**Required** Lamb, G. R., Polman, J. L., Newman, A., & Smith, C. G. (2014). Science news infographics: Teaching students to gather, interpret, and present information graphically. *The Science Teacher*, *81*(3), 25.	

	Lee, V. R., & Wilkerson, M. (2018). *Data use by middle and secondary students in the digital age: A status report and future prospects*. (skim pp. 9-43) Matuk, C., DesPortes, K., Amato, A., Silander, M., Vacca, R., Vasudevan, V., & Woods, P. J. (2021). Challenges and opportunities in teaching and learning data literacy through art. In *Proceedings of the 2021 ISLS Annual Meeting*. Bochum, Germany: ISLS. Stornaiuolo, A. (2020). Authoring Data Stories in a Media Makerspace: Adolescents Developing Critical Data Literacies. *Journal of the learning sciences, 20*(1), 81-103. (read pp. 88, 90-97, *excerpted) **Further Reading:** See special issue "Situating Data Science" in the *Journal of the Learning Sciences* edited by Wilkerson & Polman, Books by Tufte, various infographics sites, *Science and Engineering for Grades 6-12: Investigation and Design at the Center* from the National Academy of Science, Engineering, & Medicine	
Week 9 Data Science Curricula	**Required** Lee, V. R., & Delaney, V. (2022). Identifying the content, lesson structure, and data use within pre-collegiate data science curricula. *Journal of Science Education and Technology, 31*, 81-98. https://doi.org/10.1007/s10956-021-09932-1 **Further Reading: See** CourseKata from UCLA**,** new offerings current and forthcoming from Stanford University including those being produced through youcubed, see GAISE II for guidance on data science content	
Week 10 Humanizing data	**Required** Lee, V. R., Wilkerson, M. H., & Lanouette, K. (2021). A Call for a Humanistic Stance toward K-12 Data Science Education. *Educational Researcher, 50*(9), 664-672. Lee, V. R., Pimentel, D., Bhargava, R., & D'Ignazio, C. (to appear). Taking data feminism to school *British Journal of Educational Technology*.	**Data-intensive Lesson Plan Due**

	Further reading: See Hug & McNeil, *Use of Firsthand and Secondhand Data in Science; Science and Engineering for Grades 6-12: Investigation and Design at the Center* from the National Academy of Science, Engineering, & Medicine	

Please note that there is simultaneously much work that has already been done in related areas and much new work that is underway. The quarter system limits what can be covered in a single course and the commitment to keep readings short and relevant led to the current choices. Some leading and up-and-coming contributors to this area are not represented on this list but may be in future iterations. The instructor is happy to refer you to other work (vrlee@stanford.edu).