

DATASCI W210

Synthetic Capstone

Instructors: Stanislav Kelman, Coco Krumme, Joyce Shen, David Steier, Alberto Todeschini, Puya Vahabi

Course Description

In the capstone class, students combine technical, analytic, interpretive, and social dimensions to design and execute a full data science project, developing their skills as data scientists with a focus on real-world applications and situations. The final project provides an opportunity to integrate all of the core skills and concepts learned throughout the program and prepares students for long-term professional success in the field. It provides experience in formulating and carrying out a sustained, coherent, and impactful course of work resulting in a tangible data science project using real-world data. Students are evaluated on their ability to collaboratively develop and communicate their work in both written and oral form. The capstone is completed as a group project, and each project will focus on open, pre-existing, secondary data. There are relevant readings and case discussions throughout. We provide many real-world examples and perspectives, including through panel discussions with leading data science experts and practitioners.

Course Summary

This course has three main goals:

1. Practice using data science to drive significant impact by solving challenging, valuable problems (i.e., by creating new data-driven capabilities or by influencing decisions that can significantly improve mission-critical results)
2. Reinforce critical problem-solving, communication, influencing, and management skills
3. Engage in a process of teamwork, feedback, and iteration that mirrors the challenges and opportunities of applying data science in a realistic organizational setting

We begin by covering fundamentals for effective execution, including a review of the “top-management perspective,” problem structuring, selecting tools/approaches, work planning, and managing ethical and legal considerations. We then broaden our focus to leading others, managing teams, communication/presentation fundamentals, influencing in organizations, and leveraging data visualization. We conclude with advanced topics like institutionalizing data-driven decision-making, building products, and perspectives on the future of data science.

Prerequisites: Students must have completed (or are completing during the same semester) all core courses.

Course Assignments and Final Exam

The primary assignments for this course are three group presentations to the class along with a final web-based deliverable for the group project. In addition to these assignments, students are evaluated based on their participation in class discussions, and by their group-mates based on contributions to the group.

- **55% - Participation** - class discussions and group project participation
- **25% - In-class presentations** - instructor evaluation and peer feedback on presentations
- **20% - Web-based final deliverable**

Course Data Sets, Software, and Tools

This course allows students wide discretion for selecting problems, analyses, data sets, software, and tools for use on their group projects.

Students may select any problem and approach that meets their interests, affords opportunities for truly impactful results, and is feasible within the timeframe of this course. Students may select any open data sets (publically available, unrestricted) that suit their focal problem/analysis, and may use any software or tools that are appropriate for meeting their goals. Students must present and defend their choices across these dimensions throughout the course.

Students are required to thoroughly document their analyses. They are also strongly encouraged to build an end-to-end analysis pipeline covering data sourcing, cleaning/preparation, transformation, processing, visualization, interpretation, etc.

Readings and Course Pack

There is no textbook for this course. Readings are drawn from various relevant books, articles, reports, and academic papers and are made available either in the course pack or online.

Syllabus

Week 1: Intro to Capstone

Topics

- Why, when, and how data science matters
- What it means to be a data scientist

- Philosophy and mindset for data science work
- Ways in which data science is driving impact over time, along with examples
- Project and group selection (Part 1 of 2)

Required Reading

- McAfee, A. Brynjolfsson, E. Big Data: The Management Revolution. *Harvard Business Review*.
Retrieved from <https://hbr.org/2012/10/big-data-the-management-revolution/ar>
- Provost & Fawcett. (2013). Chapter 1-2. In *Data Science for Business*. O'Reilly
- Schutt & O'Neil. (2013). Chapters 1-2, 15-16. In *Doing Data Science*. O'Reilly
- LaValle, S. Lesser, E., Shockley, R., Hopkins, M. S., & Kruschwitz, N. (2011). Big data, analytics and the path from insights to value. *MIT Sloan Management Review*.
- Press, G. (2013). A very short history of data science. *Forbes*. Retrieved from
<http://www.forbes.com/sites/gilpress/2013/05/28/a-very-short-history-of-data-science/>

Optional Reading

- Zumel & Mount. (2014). Chapter 1. In *Practical Data Science with R*. Manning.
- Gozman, D., Currie, W., Seddon, J. (2015). The Role Of Big Data In Governance: A Regulatory And Legal Perspective Of Analytics In Global Financial Services. SWIFT Institute. Retrieved from <http://www.swiftinstitute.org/wp-content/uploads/2015/12/SIWP-2014-009-The-Role-of-Big-Data-in-Governance-FINAL.pdf>
- Phys.org. *Scientist helps move structural biology into 'big data' era*. (2016). Available from
<http://phys.org/news/2016-03-scientist-biology-big-era.html>

Week 2: Driving Impact

Topics

- Case example of an organization trying to use "big data" in an effective way
- The top-management perspective and its ramifications on our work
- Techniques for structured problem solving
- Methodologies for tackling data science analysis
- Project and group selection (Part 2 of 2)

Required Reading

- Chandrasekhar, R., & Parker, S. (2014). *Luminar: Leveraging big data using corporate entrepreneurship*. Richard Ivey School of Business Foundation, Version: 2014-05-20.
- Higgins, R., O'Donnell, P., Bhatt, M. (2012). Kyrus: Big Data's Search for the Killer App. Harvard Business School Case 813060-PDF-ENG.
- Davenport, T., Kim, J. (2013). Chapter 2. In *Keeping up with the Quants*. HBR Press.
- Kahneman, D. (2011). Chapter 21. In *Thinking, fast and slow* (2nd ed.). New York, NY: Farrar, Straus and Giroux.

Optional Reading

- Minto, B. (1996). *The Minto pyramid principle: Logic in writing, thinking, & problem solving*. Norfolk, VA: Minto Publishing, Inc.
- Gabarro, J. J., & Kotter, J. P. (1993). Managing your boss. *Harvard Business Review*, Reprint 93306. Retrieved from <http://www.physicianleadership.com/wp/wp-content/uploads/psc/ManagingYourBoss.pdf>

Week 3: Designing and Building Products

Topics

- Case example of innovative, agile product development/management
- Examples of exceptional products (including software products) and what makes them great
- Key ingredients for building great products, from design to engineering to product management

Required Reading

- Eisenmann, T., Wagonfeld, A. B., & Barley, L. (2012). Aardvark. Harvard Business School Case 811-064, Revised November 8, 2012.
- Kagan, M. (2008). Introduction; Chapters 1, 3–5, 11–14, 19, 21, 22. In *Inspired: How to create products customers love*. Sunnyvale, CA: SVPG Press.
- Croll & Yoskovitz, *Analytics Lessons learned*, 2013, available at www.leananalyticsbook.com

Optional Reading

- Kelley, T., & Kelley, D. (2013). Introduction; Chapters 2, 3, 6. *Creative confidence: Unleashing the creative potential within us all*. New York, NY: Crown Business.
- Patil, D. J. (2012). *Data jujitsu: The art of turning data into product*. O'Reilly Radar Report. Available from <http://www.oreilly.com/data/free/data-jujitsu.csp>

Week 4: Project Delivery and Ethics

Topics

- Examples of failed projects and the causes for their failure
- Effective project planning and delivery (philosophies, approaches, and tactics)
- Ethical quandaries for data scientists (potential causes and ways to manage risk)

Required Reading

- Ries, E. (2011). Introduction; Chapters 1, 4, 6. In *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. New York, NY: Crown Business.
- Demirkan, H., Bulent, D. (2014). Why do so many analytics projects fail?. *Analytics informs*.
Retrieved from <http://www.analytics-magazine.org/july-august-2014/1074-the-data-economy-why-do-so-many-analytics-projects-fail>
- Voosen, P. (2014). Big-data scientists face ethical challenges after Facebook study. *The Chronicle of Higher Education*. Retrieved from <http://chronicle.com/article/Big-Data-Scientists-Face/150871/>
- Edmondson, A. (2014). Fixing a weak safety culture at General Motors. *Harvard Business Review*.
Retrieved from <https://hbr.org/2014/03/fixing-a-weak-safety-culture-at-general-motors/>

Optional Reading

- Brooks, F. (1975). Chapter 2. In *The mythical man month: Essays on software engineering*. Boston, MA: Addison-Wesley.
- Ratneser, R. (2011). The menace within. *Stanford Alumni Magazine*. Retrieved from https://alumni.stanford.edu/get/page/magazine/article/?article_id=40741
- Gibney, A. (Producer and Director). (2007). *Enron: The smartest guys in the room* [Motion picture]. United States: Magnolia Pictures.
- Spear, S., & Bowen, H. K. (1999). Decoding the DNA of the Toyota production system. *Harvard Business Review*. Retrieved from <https://hbr.org/1999/09/decoding-the-dna-of-the-toyota-production-system>

Week 5: Team Dynamics and Management

Topics

- Case example of a dysfunctional team and how it was resolved
- Examples of high-performing teams in extremely difficult situations

- Factors driving team performance
- Practical tips on how to work effectively as a team, including in team meetings

Required Reading

- Snook, S., & Polzer, J. (2003). The Army crew team. Harvard Business School Case 403-131, Revised March 30, 2004.
- Davenport, T., Kim, J. (2013). Chapter 7. In *Keeping up with the Quants*. HBR Press.
- Garvin, D. A. (2013). How Google sold its engineers on management. *Harvard Business Review*. Retrieved from <https://hbr.org/2013/12/how-google-sold-its-engineers-on-management>
- Coutu, D. (2009). Why teams don't work. *Harvard Business Review*. Retrieved from <https://hbr.org/2009/05/why-teams-dont-work>
- Stanford GSB Staff. (1999). Diversity and work group performance. Stanford Graduate School of Business. Retrieved from <http://www.gsb.stanford.edu/insights/diversity-work-group-performance>
- Gilovich, T. (1991). Chapter 7, The imagined agreement of others. In *How we know what isn't so: The fallibility of human reason in everyday life*. New York, NY: Free Press.

Optional Reading

- Janis, I. (1973). *Victims of groupthink: A psychological study of foreign-policy decisions and fiascos*. Boston, MA: Houghton Mifflin Company.
- Harvey, J. B. (1988). The Abilene paradox: The management of agreement. *Organizational Dynamics*. Retrieved from <http://www.rmastudies.org.nz/documents/AbileneParadoxJerryHarvey.pdf>
- Amabile, T., Hadley, C., & Kramer, S. (2002). Creativity under the gun. *Harvard Business Review*. Retrieved from <https://hbr.org/2002/08/creativity-under-the-gun>
- Tuckman, B. W. (1965). Developmental sequence in small groups. *Psychological Bulletin*, 63(6), 384–399. Retrieved from <http://openvce.net/sites/default/files/Tuckman1965DevelopmentalSequence.pdf>
- Paramount Pictures (Producer), & Marshall, F. (Director). (1993). *Alive* [Motion picture]. United States: Paramount Pictures.
- Columbia Pictures (Producer), & Miller, B. (Director). (2011). *Moneyball* [Motion Picture]. United States: Sony Pictures Home Entertainment.
- Lencioni, P. (2002). *The five dysfunctions of a team: A leadership fable*. Indianapolis, IN: Jossey-Bass.

Week 6: Group Presentation 1

Topics

- Deliver 1st presentation

Required Reading

- None

Optional Reading

- None

Week 7: Communication and Storytelling

Topics

- Implications of top-management perspective on effective communication
- Power of storytelling and narrative, including how we can leverage it in our work
- Tactics for presenting and sharing information
- Adjustments to project approach/plan following first presentation (as needed)

Required Reading

- Heath, C., & Heath, D. (2007). Introduction; Chapters 2, 5, 6 Epilogue. In *Made to stick: Why some ideas survive and others die*. New York, NY: Random House.
- Zumel, N., Mount, J. (2014). Chapter 11. In *Practical Data Science with R*. 2014. Manning.
- Kahneman, D. (2011). Chapter 34. In *Thinking, fast and slow* (2nd ed.). New York, NY: Farrar, Straus and Giroux.
- Gilovich, T. (1991). Chapter 6, Believing what we are told. In *How we know what isn't so: The fallibility of human reason in everyday life*. New York, NY: Free Press.

Optional Reading

- Zelazny, G. (2001). *Say it with charts: The executive's guide to visual communication* (4th ed.). New York, NY: McGraw Hill.
- Peruse the following:
 - <http://www.visual-literacy.org>
 - <http://www.informationisbeautiful.net/>
 - <http://www.economist.com/blogs/graphicdetail>
 - <http://www.nytimes.com/interactive/2014/12/29/us/year-in-interactive-storytelling.html>

Week 8: Influencing as a Data Scientist

Topics

- How people and organizations process information and make decisions
- Examples of common cognitive biases and their implications on decision making
- Tactical guidance for effective influencing and consensus building

Required Reading

- Gilovich, T. (1991). Chapter 2, Something out of nothing. In *How we know what isn't so: The fallibility of human reason in everyday life*. New York, NY: Free Press.
- Kahneman, D. (2011). Chapters 1–3. In *Thinking, fast and slow* (2nd ed.). New York, NY: Farrar, Straus and Giroux.
- Gilovich, T., Vallone, R., & Tversky, A. (1985). The hot hand in basketball: On the misperception of random sSequences. *Cognitive Psychology* 17, 295-314. Retrieved from <http://psych.cornell.edu/sites/default/files/Gilo.Vallone.Tversky.pdf>

Optional Reading

- Ramachandran, V. S. (2012). Chapters 1–3. In *The tell-tale brain: A neuroscientist's quest for what makes us human*. New York: NY: W. W. Norton & Company.
- Bhatia, A. (2012). What does randomness look like? *Wired*. Retrieved from <http://www.wired.com/2012/12/what-does-randomness-look-like/>

Week 9: The Data-Driven / Data-Informed Organization

Topics

- Ways in which data science can be organized and delivered
- Examples of data-driven organizations and their unique advantages/capabilities
- Challenges to building a data-driven organization, along with potential solutions
- The role of culture, along with important values to establish and reinforce
- Adjustments to project approach/plan following second presentation (as needed)

Required Reading

- Patil, D. J., & Mason, H. (2015). *Data driven*. Available from <http://www.oreilly.com/data/free/data-driven.csp>.
- Economist Intelligence Unit. (2013). *Fostering a data-driven culture*. Available from

<http://www.economistinsights.com/technology-innovation/analysis/fostering-data-driven-culture/fullreport>

- Khalil, E., & Wood, K. (2014). Aligning data science—Making organizational structure work. Booz Allen Hamilton. Available from https://www.boozallen.com/content/dam/boozallen/documents/Aligning_Data_Science.pdf
- Novet, J. (2014). Why LinkedIn's data science reorg actually makes a lot of sense. VentureBeat. Retrieved from <http://venturebeat.com/2014/11/03/linkedin-data-scientists-analysis/>

Optional Reading

- None

Week 10: Group Presentation 2

Topics

- Deliver 2nd presentation

Required Reading

- None

Optional Reading

- None

Week 11: General Organizational Behavior and Leadership

Topics

- Challenges and opportunities for organizations undergoing major changes
- Ways in which organizations structure behavior (including incentives and culture)
- Approaches for architecting and steering organizational change in a responsible way

Required Reading

- Kerr, S. (1975). On the folly of rewarding A, while hoping for B. *Academy of Management Journal*, 18. Retrieved from <http://www.ou.edu/russell/UGcomp/Kerr.pdf>
- Singer, E. (2015). Game theory calls cooperation into question. *Scientific American*. Retrieved from <http://www.scientificamerican.com/article/game-theory-calls-cooperation-into-question1/>
- Collins, J. C., & Porras, J. I. (1994). Cult-like cultures. In *Built to last: Successful habits of visionary companies*. New York, NY: Harper Collins.

Optional Reading

- Senge, P. (1990). The leader's New Work: Building learning organizations. *MIT Sloan Management Review*. Retrieved from <http://sloanreview.mit.edu/article/the-leaders-new-work-building-learning-organizations/>
- Erickson, T., & Gratton, L. (2007). What it means to work here. *Harvard Business Review*. Retrieved from <https://hbr.org/2007/03/what-it-means-to-work-here/ar/1?referral=00134>
- Pfeffer, J. (1998). Six dangerous myths about pay. *Harvard Business Review*. Retrieved from <https://hbr.org/1998/05/six-dangerous-myths-about-pay>
- Terkel, S. (1997). *Working: People talk about what they do all day and how they feel about what they do* (2nd ed.). Fort-Meyers, FL: The News Press.
- Dixit, A. (1993). *Thinking strategically: The competitive edge in business, politics, and everyday life* (2nd ed.). New York, NY: W. W. Norton & Company.
- Bower, J. L., & Christensen, C. M. (1995). Disruptive technologies: Catching the wave. *Harvard Business Review*. Retrieved from <https://hbr.org/1995/01/disruptive-technologies-catching-the-wave>

Week 12: Possible Futures of Data Science

Topics

- Recent data science–related trends and possible futures
- Perspectives on the future of data science in terms of technology, application areas, and the profession

Required Reading

- Manyika, J., Chui, M., Bughin, J., Dobbs, R., Bisson, P., & Marrs, A. (2013). Disruptive technologies: Advances that will transform life, business, and the global economy. McKinsey Global Institute. Retrieved from http://www.mckinsey.com/insights/business_technology/disruptive_technologies. (Executive Summary)
- Brynjolfsson, E., & McAfee, A. (2012). *Race against the machine: How the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming employment and the economy*. Research Brief. Retrieved from http://ebusiness.mit.edu/research/Briefs/Brynjolfsson_McAfee_Race_Against_the_Machine.pdf
- Simonite, T. (2015). Automating the data scientists. *MIT Technology Review*. Retrieved from <http://www.technologyreview.com/news/535041/automating-the-data-scientists/>

Optional Reading

- Skim: <http://www.wolframalpha.com/docs/timeline/>

Week 13: Wrap-Up

Topics

- Recap and review
- Goodbye and parting thoughts

Required Reading

- None

Optional Reading

- None

Weeks 14 and 15: Final Group Presentations and Deliverables

Topics

- Prepare for third and final presentation.
- Deliver final presentation and submit project deliverable.

Required Reading

- None

Optional Reading

- None