

**ME209 AND ED290C**  
**ENGINEERING DESIGN AND PROTOTYPING: PEDAGOGY & ASSESSMENT**  
**W 12:30-2:00 PM; F 1-2:30 PM**  
**220 JACOBS HALL**

### **Instructor**

Alice M. Agogino, Roscoe and Elizabeth Hughes Professor of Mechanical Engineering; 415 Sutardja Dai Hall; 510-642-6450; [agogino@berkeley.edu](mailto:agogino@berkeley.edu); twitter: [agogino](#)

### **Course Description**

This graduate course explores contemporary research in engineering design and prototyping, as well as related cognitive issues in engineering curricular development, pedagogy, and assessment. One recurring theme throughout the course will be the duality between learning and design: design-based research, design as a pedagogy for integrative learning and the role of cognition and the learning sciences in the practice of engineering design. It has been motivated by several reforms: (1) National efforts to better train and educate engineers for the engineering workplace in the 21st Century: to better prepare engineers to face multidisciplinary problems and product design in competitive industries and improve their skills in teamwork and communication. (2) Efforts to improve how engineers build robust problem-solving, design and prototyping skills. (3) Advances in accessible prototyping technologies such as 3D printing and laser cutters and the popularity of the Maker movement. (4) Diversity Issues of ethnicity and gender in the engineering programs and practice. This course includes both qualitative and quantitative research methods in the pedagogy and assessment of engineering design and prototyping and coverage of key research findings. The theory will be applied to the students' graduate research or capstone projects.

### **Course Objectives**

This course has been developed to bridge student's previous knowledge of disciplinary research in design and prototyping with engineering education research.

- Provide learners the opportunity to question (usually tacit) assumptions about what engineering is, what the purpose and process of engineering education is, and who gets to be an engineer.
- Understand design as a pedagogy for integrative learning and the role of cognition and the learning sciences in the practice of engineering design and prototyping.
- Provide the participants with an understanding of theories and practices in content, assessment, and pedagogy for teaching engineering design and prototyping.

- Familiarize learners with quantitative and qualitative methodologies for data analysis associated with the assessment of design and prototyping interventions.
- Promote critical thinking and a social construction of knowledge by having face-to-face and online discussions of readings from a variety of sources.

### Student Learning Outcomes

Students will be able to:

- Identify their own role in shaping engineering and engineering education, and explore paths of connecting their disciplinary research to educational interests in design and prototyping;
- Think critically, reflectively and holistically about engineering and education;
- Become aware of the theoretical and practical issues of learning, instruction, and assessment as these concern the design of educational environments and technologies;
- Apply design research methods to inform and validate designs involving educational issues; and
- Articulate their own view of the design of educational tools and become more confident about their ability to work as an engineer and educational designer.

### Topics Covered

1. Philosophy and epistemology of education and engineering
2. Learning Process: How people learn
3. Research methods: Qualitative and quantitative
4. Creativity and project-based learning
5. Motivation and diversity in learning strategies
6. Design thinking and learning
7. Constructivism and constructionism
8. Design, making and prototyping
9. Education, engineering and technology as an agents of emancipation
10. Assessment
11. K-12 education and recruitment
12. Diversity and equity in engineering: Women and underrepresented minorities

### Credit

**Units:** 3.0 units

**Credit:** Letter Grade

**Final Exam:** No room required; project report in lieu of exam.

### Assessment of Student Progress Toward Course Objectives

- 30% on assignments
- 40% on attendance and participation in class
- 30% on application to graduate research or capstone project

## Class Participation

Students are considered co-producers of each class. They are encouraged to engage in deep, critical and respectful discussion to promote the social construction of knowledge. Learners are expected to actively participate in the discussions and share their ideas, as well as lead the discussions. At the beginning of the semester, each student is assigned to lead 1-2 topics with one other student partner, throughout the semester. Students are encouraged to discuss their assigned work with the instructor one week prior to their presentation to go over the reading material and approach to the discussion. Additionally, each week learners will post their reactions to at least one of the readings based on their own experiences.

## Individual Assignments

Individual assignments will allow the students to reflect about some of the concepts being taught in the class. These are due at the start of each class, unless otherwise noted. Late assignments are discouraged but accepted. The penalization is 20% of the total score (20 points out of 100) for each day of delay.

All individual assignments are to be submitted via the bcourse "assignments" tab under the appropriate heading prior to the start of class on the day they are due.

## bCOURSES Website

We will make extensive use of the course website to both communicate information to you and to converse with you about your readings, homework and your projects.

## Schedule & Readings

(All required readings will be available online)

### **WEEK 1 (8-24/8-26):** Philosophy and epistemology of education and engineering

- [Noddings, Nel. "The Philosophical and Educational Thought of John Dewey." \*Philosophy of Education\*. 3rd ed. Boulder, CO: Westview, 2012. 23-42.](#)
- [Van de Poel, I., & Goldberg, D. E. \(Eds.\). \(2010\). \*Philosophy and engineering: An emerging agenda\* \(Vol. 2\). Springer Science & Business Media.](#)
- [Figueiredo, A. D. \(2008\). "Toward an Epistemology of Engineering". In D. Goldberg and N. McCarthy, eds., \*Proceedings Workshop on Philosophy & Engineering \(WPE 2008\)\*, Royal Engineering Academy, London, November 2008. pp. 94-95.](#)

#### **Optional:**

- Noddings, Nel. "Philosophy of Education Before the Twentieth Century." *Philosophy of Education*. 3rd ed. Boulder, CO: Westview, 2012. 1-22.
- [Bucciarelli, Louis. \(2003\). \*Engineering Philosophy\*. Delft University Press. pp. 1-22](#)

- [Lawson, Bryan and Kees Dorst \(2009\). Chapter 2: “Understanding Design.” From Design Expertise, pp. 23-80. Architectural Press: Boston.](#)
- [Petroski, Henry. \(1996\) Invention by Design: How Engineers Get from Thought to Thing. Chapter 1 and Chapter 5: Aluminum Cans and Failure.](#)

**WEEK 2 (8-31/9-2):** Learning Process: How People Learn

- [Bransford, J.D., Brown, A., & Cocking, R.R. \(2000\). How People Learn: Brain, Mind, Experience, and School: Expanded Edition. Chapter 1: Learning: From speculation to science \(pp. 1-28\). Washington, DC: National Academy Press.](#)
- [Brown, J.S., Collins, A., and Duguid, P. \(1989\). Situated cognition and the culture of learning. Educational Researcher, vol. 18, no. 1.](#)
- Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes. Chapter 6: Interaction between learning and development (pp. 79-91). Cambridge, MA: Harvard University Press

**Optional:**

- [Hsi, S. and A.M. Agogino, "Scaffolding Knowledge Integration through Designing Multimedia Case Studies of Engineering Design," Engineering Education for the 21st Century: Proceedings of Frontiers in Education, FIE'95, ASEE/IEEE, pp. 4d1.1-4d1.4.](#)
- [Krathwohl, D. R. \(2002\). A revision of Bloom's taxonomy: An overview. Theory into practice, 41\(4\), 212-218.](#)
- Duckworth, E. (1987). The Having of Wonderful Ideas. Teachers College Press. Chapter 1. pp. 1-14.

**WEEK 3 (9-7/9-9):** Research methods

- [Olds, B.M., Moskal, B.M., and Miller, R.L. \(2005\) “Assessment in engineering education: Evolution, approaches and future collaborations”, Journal of Engineering Education.](#)
- [Designing for Humans: an Ethnography Primer,” IDSA, 2010.](#)

**Optional:**

- Laurel, Brenda, Design Research: Methods and Perspectives. Qualitative methods: from boring to brilliant. pp. 23-29. Overview of quantitative methods in design research. pp. 63-69

**WEEK 4 (9-14/9-16):** Creativity and project based learning

- [Resnick, M. \(2007\). All I Really Need to Know \(About Creative Thinking\) I Learned \(By Studying How Children Learn\) in Kindergarten. Proceedings](#)

[of the ACM SIGCHI conference on Creativity & Cognition, Washington, DC.](#)

- [Blumenfeld et al \(2000\), Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning, Educational Psychologist, 1532-6985, Volume 26, Issue 3, 1991, Pages 369 - 398.](#)

**Optional:**

- [Dorst, K and Cross, N \(2001\), Creativity in the Design Process: co-evolution of problem-solution, Design Studies, Vol. 22, No. 5, pp. 425-437.](#)

**WEEK 5 (9-21/9-23):** Motivation and diversity in learning strategies

- [Reis, Rick. Student Motivation: Problem Solved?](#)
- [Felder, R. M., & Silverman, L. K. \(1988\). Learning and teaching styles in engineering education. Engineering education, 78\(7\), 674-681.](#)
- [Joi Ito's blog posts: Formal vs Informal Education.](#)
- Lau, K., A.M. Agogino, and S. Beckman (2012). "Diversity in Design Teams: An Investigation of Learning Styles and their Impact on Team Performance and Innovation," *International Journal of Engineering Education*, 28, No. 2, pp. 293-301.

**Optional:**

- Wigfield, A., Eccles, J.S., Schiefele, U., Roeser, R.W., & Kean, P.D. (2006). Development of achievement motivation. In W. Damon & R.M. Lerner (Series Eds.) & N. Eisenberg (Volume Ed.), *Handbook of Child Psychology, 6th Edition, Vol. 3, Social, Emotional and Personality Development*. New York: Wiley.

**WEEK 6 (9-28/9-30):** Design thinking and learning

- [Dym, C.L., A.M. Agogino, O. Eris, D.D. Frey and L.J. Leifer, "Engineering Design Thinking, Teaching and Learning," Journal of Engineering Education, Jan. 2005, v. 94, no. 1.](#)
- [Beckman, Sara L., and Michael Barry \(2007\). "Innovation as a Learning Process: Embedding Design Thinking." California Management Review 50, no. 1: 25 - 56.](#)
- Beckman, Sara L., and Michael Barry (2012). "Teaching Students Problem Framing Skills with a Storytelling Metaphor," *International Journal of Engineering Education* 28, no. 2, pp. 364-373.

**Optional:**

- [Owen, C. L. \(2005, October\). Design Thinking. What It Is. Why It Is Different. Where It Has New Value. In Proceedings of the International Conference on Design Education and Research \(pp. 96-112\)](#)

**WEEK 7 (10-5/10-7):** Constructivism and constructionism

- [Papert, S. \(1980\). Mindstorms: Children, Computers, and Powerful Ideas. Basic Books. Foreword, Introduction.](#)
- [Ackermann, E. \(2001\). Piaget's constructivism, Papert's constructionism: What's the difference? Future of learning group publication, 5\(3\), 438.](#)
- [Papert, S. \(2000\). What's the big idea? Toward a pedagogy of idea power. IBM Systems Journal, 39\(3/4\), 720.](#)

**Optional:**

- Papert, S. (1980). Mindstorms: Children, Computers, and Powerful Ideas. Basic Books. Chapter 1, Chapter 3, Chapter 8.
- Turkle, S. (2007). "Evocative Objects: Things We Think With." Introduction and selected essays.

**WEEK 8 (10/12/10/14):** Design, making and prototyping

- [Blikstein, P. \(2013\) Digital Fabrication and 'Making' in Education: The Democratization of Invention.](#)
- [Jordan, S., & Lande, M. \(2013, October\). Should Makers be the engineers of the future?. In Frontiers in Education Conference, 2013 IEEE \(pp. 815-817\). IEEE](#)
- ["Prototyping Is The Shorthand Of Design", IDEO.](#)
- [Sandhu, Jaspal S.\(Jan. 2013\) "Measure early, measure often: rapid, real-time feedback in design for social innovation".](#)
- **Scan:** [Build Methods on theDesignExchange](#)

**WEEK 9 (10-19/10-21):** Education, engineering and technology

- [Blikstein, P. \(2008\) Travels in Troy with Freire: Technology as an Agent for Emancipation. in Noguera, P. & Silva, C. A. \(eds.\). Freire and the Possible Dream. Sense Publishers, Rotterdam.](#)
- [Kulkarni, C., M. S. Bernstein, and S.R. Klemmer \(2014\). How do we harness the scale and diversity of an online class? In Learning with MOOCS, a Practitioner's Workshop.](#)
- [Gerard, L., J. M. Vitale, D.F. Donnelly and M.C. Linn \(2016\) "Combining Automated Scoring and Teacher Guidance to Improve Students'](#)

[Science Learning”, Proceedings of the American Educational Research Association \(AERA\) Conference.](#)

**Optional:**

- Freire, P. (2000). Pedagogy of the oppressed. Bloomsbury Publishing.

**WEEK 10 (10-26/10-28):** Assessment

- (Video) [Assessment: The Silent Killer of Learning / Eric Mazur](#) (start at minute 8:30)
- [ABET Accreditation Assessment Planning.](#)
- [Hey, J.H., A.P Van Pelt, A.M Agogino, and S. Beckman, "Self-Reflection: Lessons Learned in a New Product Development Class," Journal of Mechanical Design, ASME, Vol. 129, No. 7, July 2007, pp. 668-676.](#)
- Cobb, C.L. J. Hey, A.M. Agogino, S.L. Beckman, and S. Kim, "[What Alumni Value New Product Development Education: A longitudinal Study,](#)" special issue of *ASEE Advances in Engineering Education*, 5 (1) pp. 1-37, 2016.

**Optional:**

- [Black, P., & Wiliam, D. \(2010\). Inside the Black Box.](#)
- [Worsley, M., & Blikstein, P. \(2014\). Analyzing Engineering Design through the Lens of Computation. test, 1\(2\), 151-186.](#)

**WEEK 11 (11-2/11-4):** K-12 education and recruitment

- [Martin, L. \(2015\). The promise of the Maker Movement for education. Journal of Pre-College Engineering Education Research \(J-PEER\), 5\(1\), 4.](#)
- [Resnick, M., and Silverman, B. \(2005\). Some Reflections on Designing Construction Kits for Kids. Proceedings of Interaction Design and Children conference, Boulder, CO.](#)
- [Oh, H., Eisenberg, M., Gross, M. D., & Hsi, S. \(2015, June\). Paper mechatronics: a design case study for a young medium. In Proceedings of the 14th International Conference on Interaction Design and Children \(pp. 371-374\). ACM.](#)

**Optional:**

- [Next generation science standards: Science and Engineering Practices](#)
- [Next generation science standards: Three dimensional learning](#)
- [Eisenberg, M., Oh, H., Hsi, S., & Gross, M. \(2015, September\). Paper mechatronics: A material and intellectual shift in educational technology. In \*Interactive Collaborative Learning \(ICL\), 2015 International Conference on\* \(pp. 936-943\). IEEE.](#)

**WEEK 12 (11-9/11-11):** Diversity and equity in engineering: Women and underrepresented minorities

- Steele, Claude, A Threat in the Air: How Stereotypes Shape Intellectual Identity and Performance, *American Psychologist*, Vol. 52 (6), June 1997, pp. 613-629.
- [Oehlberg, L., Shelby, R., & Agogino, A. \(2010\). Sustainable product design: Designing for diversity in engineering education. \*International Journal of Engineering Education\*, 26\(2\), 489-498.](#)
- (Video) [Thinking About Making - An examination of what we mean by making \(MAKEing\) these days. What gets made? Who makes? Why does making matter? - Leah Buechley](#)
- [Turkle, S., & Papert, S. \(1990\). Epistemological Pluralism. \*Signs\*, vol. 16, no. 1.](#)
- [Hsi, S., M.C. Linn, and J. E. Bell \(1997\) "The Role of Spatial Reasoning in Engineering and the Design of Spatial Instruction," \*Journal of Engineering Education\*, 86 \(2\) pp. 151-158.](#)

**Optional:**

- (Video) [Young, Valerie, "Overcoming the Imposter Syndrome"](#)
- [Weinbaum, Sheldon, "Fulfilling the Dream: The Importance of Doing What You Believe and Being Taken Seriously"](#)
- Huang, Gary, Bebiyu Taddese and Elizabeth Walter, "Entry and Persistence of Women and Minorities in College Science and Engineering Education," *Education Statistics Quarterly*, Vol. 2, (3), 2000.
- Margolis, Jane and Allan Fisher, *Unlocking the Clubhouse: Women in Computing*, The MIT Press, 2003. (not available online)

**WEEK 13 & 14 (11-16/ 11-18 & 11/30-12-2):** Project presentations

Final presentations in class will be reviewed by peers and instructors.

**WEEK 15:** Reading, Review and Recitation

Students will also be invited to receive feedback through Jacobs' Design Showcase.