ENGR490
Breakthrough Thinking for Complex Challenges

Course: ENGR-49000 "Breakthrough Thinking for Complex Challenges"

Description: In this course, students engage in problem exploration and participatory design in close partnership with an external organization to frame, design, and advance holistic solutions to major challenges varyingly categorized as complex problems, grand challenges, or wicked problems. These categories of problems share the characteristics of being ambiguously bounded, involving multiple stakeholders and inter-dependencies, and displaying non-linear emergent behavior, network effects, and hysteresis, and require solutions that span technical, economic, social, and cultural domains. Conceived solutions focus on two or more aspects of the major challenge, and may include means to address technical challenges, aspects of stakeholder education and awareness, cultural adoption, resource availability and access, economic and operational sustainability, or governance. Collectively, co-designing solutions with a holistic perspective of the aforementioned components, in collaboration with involved stakeholders, helps build critical awareness and skills consistent with the College's vision to prepare Purdue engineers for leadership roles in the 21st century.

Pre-requisites: For students pursuing the Minor in Innovation and Transformational Change this course should be the last course in their 6 course sequence.

Instructor: Professor Joe Sinfield **Office:** HAMP G231 **Phone:** x6-2742

Class hours: Two meetings per week: (1) 50 min + (1) 110 min

Classroom: TBD

Learning outcomes: Upon successful completion of this course, students will be able to:

1. Employ rigorous issue analysis methods to develop mutually-exclusive collectively-exhaustive structured inventories of the issues involved in a major challenge
2. Understand stakeholder motivation and interpret the funds, services, and influence exchanged in stakeholder ecosystems
3. Understand the benefits and limitations of qualitative and quantitative methods to identify and interpret stakeholder needs
4. Gain familiarity with habit conversion methodologies and the role they can play in design activities
5. Recognize the importance of empathy in solution design and apply structured ideation methods to engender empathy in designers
6. Understand patterns of innovation success and the contextual

circumstances in which they apply
7. Understand combinatorial business design methods to explore and prioritize alternative paths to achieve financial sustainability for an idea
8. Discern the broader societal impacts of design activities
9. Develop robust assessments of the assumptions underlying new ideas and means to test those assumptions rapidly and at low cost
10. Recognize and define influence paths and communication methods to drive awareness, consideration, conversion, and retention of new solutions

Alignment with standards:

ABET Standard	***Corresponding Course Content***
A. Ability to apply mathematics, science and engineering principles	Team project involving designing and iteratively testing aspects of holistic solutions for complex challenges
C. Ability to design a system, component, or process to meet desired needs	Team work sessions and lecture content on issue and ecosystem analysis and stakeholder definition; lectures on systems thinking and solution right-sizing; team work session on systems-level solution prioritization
D. Ability to function on multidisciplinary teams	Team project involving multidisciplinary student teams; team work session and lecture on ideation best practices
E. Ability to identify, formulate, and solve engineering problems	Lectures on problem framing, hypothesis-driven problem solving, and leveraging structure and analogies to generate solutions; term project and collaborative co-design requiring development of aspects of holistic solutions to a major challenge
G. Ability to communicate effectively	Lecture on persuasive communications, ghosting, storylines, and storytelling; team oral presentations in class and to engaged partner organization
H. The broad education necessary to understand the impact of engineering solutions in a global and societal context	Team project and course content centered around designing for major challenges
J. Knowledge of contemporary issues	Lecture and case discussions focused on addressing major

	societal challenges
K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Lectures and multiple problem solving sessions on design, linking quality to context, and identifying barriers to uncover paths to breakthrough opportunity

Relation to Engineer of 2020 Target Attributes

Target Attribute	***Corresponding Course Content***
Decision-making ability	Team working sessions on systems-level solution prioritization; lecture on the many forms of risk
Ability to synthesize engineering, business, and societal perspectives	Team working sessions and lecture on multifaceted sustainability (operational, economic, environmental and cultural)
Open-ended design and problem solving skills	Term project aimed at framing and addressing major challenge that has no discreet solution path or solution; See also ABET standards A, C, E, and K; lecture on developing an outside-in perspective on solutions
Analytical skills	Lectures and iterative team working sessions to gather, analyze, and interpret multiple forms of technical, economic and social data; See also ABET standard C
Innovative mindset	Lecture on forms of innovation and impact; case studies illustrating achievement of high-impact innovation and innovator attributes
Adaptability in a changing environment	Team work sessions and lectures on ecosystem analysis, habit conversion, stakeholder influence and communication strategies

Grading:

Weight	Activity
65%	Term project team assignments: The term project for the class centers on a multifaceted problem representative of a major societal challenge that is provided by an external organization. Students in the class divide into teams of 3 to 5 and engage with the external organization and key stakeholders in problem framing and co-design activities leading to the development of

	key aspects of holistic solutions to help address the organization's challenge. Team assignments consist of 6 to 8 interim deliverables (e.g., issue analysis, stakeholder maps, context characterization, holistic solution requirements, solution design space definition, prioritization criteria development, system-level solution selection, and assumption analysis) that are developed by the teams over the course of the semester and shared with the external organization as they work their way through framing and developing aspects of solutions to address the provided challenge.
35%	Homework and cases: Brief individual written assignments (< 3 pages) are employed to guide students through exploration of course concepts and cases illustrating discussed design principles and behaviors (typically 3-5 assignments)

Text: **Innovator's Guide to Growth: Putting Disruptive Innovation to Work** by Scott D. Anthony, Mark W. Johnson, Joseph V. Sinfield, and Elizabeth J. Altman

Attendance: Due to the nature of this class, class participation is a must. In order to receive course credit and a full grade, a student must:

1. Have no more than two unexcused absences.
2. Satisfactorily complete ALL assignments.

Three unexcused absences will result in a grade reduction of one letter grade. Four unexcused absences will result in a grade of 'I' or 'F', depending on whether or not the student is considered to be passing in all other aspects at the time of the fourth absence. Failure to complete ALL assignments will result in a grade of 'I' or 'F', depending on whether or not the student is considered to be passing in all other aspects.

Homework/ cases/project deliverables: No assignments can be missed without penalty, unless the missed assignment is authorized by the instructor.

Ethics: Students are expected to uphold all university policies and regulations on academic integrity and conduct. Academic dishonesty will not be tolerated, and any acts of academic dishonesty will be dealt with on a case by case basis. Penalties for violations will be levied at the discretion of the instructor and may include but are not limited to reduction in the grade received for an assignment or exam, loss of credit for an assignment or exam, reduction in the FINAL grade for the course, and/or failure of the course.

Course outline:

Week	*Topic*		*Reading/References*
1	I.	Addressing grand challenges	Sinfield and Solis, 2016b
2	II.	Forms of innovation / defining impact	Solis and Sinfield, 2014
3	III.	Design thinking and achieving breakthrough	Breakthrough Case #1; Sinfield and Solis, 2016b; Crismond and Adams, 2012
4,5,6	IV.	Issue analysis; hypothesis-driven problem solving	Minto, 1996
7,8	V.	Framing a problem; ecosystem analysis; stakeholder engagement	Belone et al., 2016
9	VI.	Making a problem personal; jobs-to-be-done and ethnography	Anthony et al., 2007; Beebe, 2014
10	VII.	Developing an outside-in perspective on solutions	Solis and Sinfield, 2016a
11	VIII.	Systems thinking; patterns of innovation success	Breakthrough Case #2 DeLaurentis and Callaway, 2004; Mostafavi et al., 2011
11	IX.	Focusing on context to “right size” solutions	Sinfield, 2007
12	X.	Ideation best practices and stimuli development	Sinfield and Anthony, 2006; Sinfield et al., 2014; Girotra et al., 2010
13,14	XI.	Business model innovation to facilitate economic sustainability	Weill et al. 2004; Johnson et al. 2008; Sinfield et al. 2012
14	XII.	The many forms of risk	Damanpour, 1996; Sinfield and Solis, 2016a
15	XIII.	Persuasive communications; ghosting, storylines, and storytelling	Breakthrough Case #3
16	XIV.	Planning to learn	Mintzberg and Waters 1985; McGrath and MacMillan 1995

Reading list: Readings will be drawn from the following references

1. Anthony, S. D., and Sinfield, J.V. (2007) "Product for Hire: Master the Innovation Lifecycle with a Jobs-to-be-Done Perspective of Markets,"*Marketing Management*, March/April, 19-24.
2. Beebe, J. (2014). **Rapid Qualitative Inquiry: A Field Guide to Team-Based Assessment**, Second Edition. Lanham MD: Rowman & Littefield. 258 pp.
3. Belone, L., Lucero, J.E., Duran, B., Tafoya, G., Baker, E.A., Chan, D., Chang, C. Greene-Moton, E., Kelley, M. A., and Wallerstein, N., (2016). "Community-Based Participatory Research Conceptual Model: Community Partner Consultation and Face Validity," *Qualitative Health Research*, 26(1): 117-135.
4. Crismond, D. P., and Adams, R. S. (2012). "The Informed Design Teaching and Learning Matrix." *Journal of Engineering Education*, 101(4), 738-797.
5. Damanpour, F. (1996). "Organizational Complexity and Innovation: Developing and Testing Multiple Contingency Models." *Management Science*, 42(5), 693 - 716.
6. DeLaurentis, D., & Callaway, R. (2004). "A systems-of-systems perspective for public policy decisions." *Review of Policy Research*, 21(6), 9.
7. Girotra, K., Terwiesch, C., and Ulrich, K. T., (2010) "Idea Generation and the Quality of the Best Idea", *Management Science*, Vol. 56, No. 4 (April 2010), pp. 591-605.
8. Johnson, M., Christensen, C., and Kagermann, H. (2008). "Reinventing your business model." *Harvard Business Review*, December, 51-59.
9. McGrath, R., and MacMillan, I. (1995). "Discovery-driven planning." *Harvard Business Review*, 73(4), 44-54.
10. Minto, B. (1996) **The Minto Pyramid Principle: Logic in Writing, Thinking, and Problem Solving**, Minto International, Inc., London.
11. Mintzberg, H., and Waters, J. (1985). "Of strategies, deliberate and emergent." *Strategic Management Journal*, 6(3), 257-272.
12. Mostafavi, M., Abraham, D., DeLaurentis, D., and Sinfield, J. (2011). "Exploring the Dimensions of Systems of Innovation Analysis: A System of Systems Framework." *IEEE Systems Journal*, 5(2), 256 - 265.
13. Sinfield, J. and Anthony, S. (2006) "Constraining Innovation: How Developing and Continually Refining Your Organization's Goals and Bounds Can Help Guide Growth", *Strategy & Innovation*, November – December, v. 4, n. 6, 1, 6-9.
14. Sinfield, J.V., (2007) "Gives, Gets, and the Good Enough: A methodical, consumer driven approach to cutting features, benefits—and costs", *Strategy & Innovation*, November – December, v. 5, n. 6, 1, 6-10.
15. Sinfield, J.V., and Solis, F., (2016a) "Finding a Lower-risk Path to High-impact Innovations," **Sloan Management Review**, 79-89,

Summer.
16. Sinfield, J.V., and Solis, F., (2016b) “Thinking Big to Address Major Challenges: Design and Problem-Solving Patterns for High-Impact Innovation, National Academy of Engineering, *The Bridge*, 11-18, Summer.
17. Sinfield, J.V., Calder, E.S., Colson, S., McConnell, B., (2012) “How to Identify New Business Models,” *Sloan Management Review*, v. 53, n. 2, Winter.
18. Sinfield, J.V., Gustafson, T., and Hindo, B. (2014) “The Discipline of Creativity,” *Sloan Management Review*, 55(2), 24-26, Winter.
19. Solis, F. and Sinfield, J.V. (2014) “Rethinking Innovation: Characterizing Dimensions of Impact,” ASEE Annual Conference, 360 Degrees of Engineering Education, June 15 - 18, 2014 Indianapolis, Indiana, Paper ID #9284.
20. Solis, F., and Sinfield, J.V., (2016) “From Entrepreneur to Designer: The Transferable Design Principles of the Entrepreneur,” (2016) ASEE Annual Conference & Exposition, Jazzed about Engineering Education, June 26-29, 2016, New Orleans, LA, Paper ID#15965.
21. Weill, P., Malone, T. W., D’Urso V.T., Herman, G. and Woerner S. (2004) “Do Some Business Models Perform Better Than Others?” MIT Sloan School of Management Working Paper/ MIT Center for Coordination Science Working Paper No. 226, 6 May.