MSE 593.033: Technology Drivers of Innovation, Business, and Entrepreneurship

Class Syllabus – v.6 – (subject to change)

Instructor: Prof. Max Shtein – http://www.mse.engin.umich.edu/people/mshtein
+ Guest speakers

Time & place: Wednesdays, 5.30 – 8.30 pm, 1008 EECS

Course background: Human civilization has produced several major technology-driven revolutions: agricultural, industrial, computer / information, and biotech. These revolutions enabled the mass production and consumption of food, goods, electronics, information, and new biological entities. At each stage, technological innovation created enormous new pools of value, giving birth to unprecedented industries and professions. Indeed, technology is considered the "lever of riches", historically responsible for economic development and global improvement in the standard of living. In the 20th and 21st centuries, particularly in the US, tech-driven innovation has created more wealth than in all the preceding epochs combined.

In more recent decades, however, we began to recognize that *recipes for success* in the previous centuries can become *recipes for disaster*:

1. Over-reliance of traditional heavy industries on natural resources can lead to pollution and adverse climate change,
2. Industrialization of food production has resulted in mass animal cruelty and is implicated in the obesity epidemic,
3. Wide availability of pain management drugs has been tied to the opioid epidemic,
4. Social media and information overload have created new sources of stress,
5. Genetic modification technology has introduced new ethical dilemmas,
6. Creation of unprecedented wealth accompanied by lopsided distribution, and so on.

It's clear that along with the promise of prosperity, new technologies present new challenges, particularly when we consider their scale-up to deliver their benefits to more people.

Scale-up requires investment of resources (time, capital, etc.) and, hopefully, realizing a positive return on that investment. In other words, scale-up involves commercialization. And successful commercialization requires a sound business model. Unfortunately, tales of original innovators (both individuals and companies) failing (going out of business or dying poor) abound. Henry Chesbrough, a well-known organizational theorist and originator of the concept of "open innovation" wrote in his 2010 article Business Model Innovation: Opportunities and Barriers:

> *"Technology by itself has no single objective value. The economic value of a technology remains latent until it is commercialized in some way via a business model. The same technology commercialized in two different ways will yield two different returns."*

Modern-day innovators are less and less willing to give away the lion share of the positive returns on the value they create to financiers. In seeking long-term success and to capture more of the created value, equal attention should be given to designing a strong business model, with a clear path for producing, distributing, pricing, servicing, and monetizing the innovation. Furthermore, successful companies must be able to scale up, achieve a dominant market position within their domain, and be ready to pivot as technologies and consumer needs evolve. On a broader, societal level, we are also interested in job creation and equitable distribution of newly created wealth.

Course objectives: In this course we will consider key questions on the path of technological innovation and commercialization, learn to link technology attributes with viable business models, and apply our learnings to guide our research and development activities. We will:

- Learn to identify exciting new technology-driven business opportunities
- Learn to recognize business models, the "What, When, Who, and Why"
- Find ways to improve business models in ways that uniquely leverage their technological basis
- Invent and experiment with new business models; (finding ourselves in the midst of one (or more) technology revolution, it's almost impossible not to invent a new business model)
- Meet and learn from other tech entrepreneurs about their new technologies and paths

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Course Outline: Everyone is an investor. What are *you* investing in? What is the *capital* you're investing? What is the risk to your capital, and what is the risk of *not* making this investment? One of the things we want to examine in this class is the tension between risk of investing in a technology / venture that fails, and the risk of *not* investing in a technology / venture that succeeds. This tension often arises between people of different personality types, in different industries, and among cultures. The Midwest culture has become known for guarding against Errors of Commission (don't do anything that *might* result in failure!), whereas Silicon Valley has become known for guarding against Errors of Omission (don't miss out on what may turn out to be the Next Big Thing!). But it wasn't so long ago that Michigan-based Henry Ford, against all convention and custom at the time, completely revolutionized automobile manufacturing, and in the process changed all manner of manufacturing in the US and the world, established new employment and living standards, and became an emulated leader of industry.

To make a difference in people's lives at scale, as technologists, we *must* think about how our discoveries and inventions will get commercialized. We will ask: what are the *business models* by which technology gets put on firm footing, generates sustained profits, and provides service to people that purchase and use its output? (Even when focusing on fundamental academic research, there's a need to differentiate one's output from that of others, get other researchers to *pay* attention to one's research output, and find ways of financing the equipment, materials, and other resources needed to continue it.)

This course is designed to be different from other courses: We will consider technologies and applications, both emerging and established, combine theory & practice, learn by asking questions & doing (some student activity every session), and meet with tech entrepreneurs to learn about the opportunities, dilemmas and choices they faced, and the paths they took. While many (most?) entrepreneurship courses focus on the business aspects of such endeavors, in this class we will focus on the unique *technological factors* that combined to enable Henry Ford's innovations. We will also apply the same lens to focus on major breakthroughs of other noted technologist innovators.

Key concepts:

School:	Many grades, few consequences
Life:	No grades, big consequences
Culture:	Guarding against Errors of Commission *vs.* Errors of Omission
Technology:	Lever of riches, but does not create value by itself – needs a business model
IP:	Intellectual propert(ies), rights, legal monopolies
Business:	Systems approach to identify viable business structure and model
Biz model:	What do we mean by *"Business model"?* (Create, deliver, & capture value)
Value Prop:	What do we mean by *"Value proposition"*? Who creates value? Who captures value?
Startups:	Role of startup, life of startup, culture of a startup, perils of a startup, art of the startup
Systems:	Systems thinking & network effects; the 5-component model
Growth:	Exponential growth, Moore's law vs. Eroom's law
ROI:	Businesses with diminishing returns vs. those with increasing returns
Pareto:	Trade-offs, Optimization, Markets, Productivity, Team dynamics, etc.
Innovation:	Pursue product-market fit *vs.* not making a "faster horse"; Innovation as a growing space
Skeuomorphs:	Horseless carriage, iPhone
Platforms:	Where makers & users meet, Inheriting the kingdom
Money:	Revenue vs. profit, Value / market capitalization, money now vs. later, capitalization
Of unicorns:	What fairy tales teach us about life and business by way of economic and tech narratives

Reading:

My Life and Work* -Ford & Crowther;
Zero to One* -Peter Thiel;
Art of the Start -Guy Kawasaki;
Platform Revolution -Parker;
Loonshots -Safi Bahcall;
Scalable Innovation…* -Shteyn & Shtein

+ additional sources & topics throughout the term

** required reading; available as free downloads*

Which coursework / topics would be useful for connecting to which business opportunities / practices… And vice versa…

"Business Model" – ad revenue, subscription, freemium, outsourcing, goods vs. services, pricing strategies, one-time sale vs. recurring sales

"Platform" / "Platform Technology" – not a lot comes to mind, what tech is used to build / distribute / ensure access

→ Amazon as a platform?.. – distribution channels, etc.

Finding, gathering / collating, excerpting information for proposals, pitches, etc.

→ Intro to a few topic areas, then form teams based on interests (in biotech, materials, energy, transportation, computing, etc.)

Rough outline of brainstorming session topics (*lectures will cover key concepts outlined above*):

Jan. 10, 2022: Session 1 – Questionnaire, Intros, Definitions, Cultures, Opportunities, 3LPs
Part 1: Where is my flying car? About the instructor. Tech vs. Applications; Activity – Identify new / emerging domains; Specify criteria; Define "opportunity." Report out. Redefine opportunity *via* 2 (4) kinds of freedom. What's there and how would you recruit talent to this domain / team? What is the nature / size of the opportunity? (Think in orders of magnitude… new tech, $1M vs. $100M / $1B / $1T.)
Prompts – Why was Zuckerberg willing to sell his company for $30M in the beginning, but not for $1B later? Why was Google willing to sell their search tech for $1.5M initially? Was Twitter worth $44B?
Part 2: The Three Little Pigs – collapse of viable technologies due to new threat; 3LPs 2.0 – what next?
Part 3: Use of AI / LLMs in this class – encouraged! As a tool beyond search. Homework for Session 2.

Jan. 17, 2022: Session 2 – Competition vs. Monopoly, Intellectual Property – *Guest: Prof. K. Alfano*
Part 1: Guest speaker, Prof. Ken Alfano – scientist, engineer, entrepreneur, instructor, book author, intellectual property expert. Q&A – Bring questions!
Part 2: Activity – Form teams; Group and down-select domains; Identify within domain: products, technologies, components, methods, materials, ideas / facts / questions (exploratory).
Report out – what's there and how would you recruit talent to this domain / team? What is the nature / size of the opportunity? (New tech, $10k vs. $100k vs. $1M vs. $100M vs. $1B vs. $1T payoff?)
Prompts – Worked example in OLEDs; QLED TV; Introduce Value Prop.

Jan. 24, 2022: Session 3 – Survey & Drill-down, SWOT, Unknowns, Value Proposition, Teams
Activity – Describe sources of value & value proposition(s): different products offer different value propositions in different applications. (Note: in describing value propositions in emerging domains / products, describe use cases. "Design thinking.")
Report out – what's there and how would you recruit talent to this domain / team? What is the nature / size of the opportunity? (Again, think in $10k vs. $100k vs. $1M vs. $100M vs. $1B vs. $1T increments)
Prompts – What are the types of risks? How would you de-risk each? How much are you willing to spend vs. the expected return?

Jan. 31, 2022: Session 4 – What does the customer need?
Activity – Back-casting exercise: re-define products, services, and technologies that make a difference in the use cases described in Session 3.
Report out – what's there and how would you recruit talent to this domain / team? (Cost/benefit of de-risking – $10k vs. $100k vs. $1M vs. $100M vs. $1B vs. $1T)
Prompts – What is the nature / size of the opportunity? Risks? ROI?

Feb. 7, 2022: Session 5 – Value proposition / Delivery / Scaling (Steady State *vs.* Startup)

Activity – Roadmapping exercise: what are the business models that support the product, services, and technologies from Session 4.
Report out – what's there and how would you recruit talent to this domain / team? What is the nature / size of the opportunity? (new tech, $1M vs. $100M vs. $1B vs. $1T) Pick your role(s): Startup or existing (large) company? What is the business plan?
Prompts – What level of financing is considered "Series A" in IT, electronics, transportation, biotech?..

Feb. 14, 21, ~~28~~; March 6, 13, 20, 27: Sessions 6-11 – Pivot; New Domains of technology & application; Special Guests
Activity – Scramble / mix teams; Grow your requirements & goals: identify value chain / system, partnerships, capital requirements, sources of funding, timing, cap table, incentives, etc.
Report out – what's there and how would you recruit talent to this domain / team?
Prompt – what is the scale of your growth? What is a "down round" & how do you avoid it for your startup specifically?

Note – No Class on: Feb. 28 - SPRING BREAK;

Apr. 3, 10, 17, 2022: Wrap-ups & other topics – Session 12, 13, 14

Grading: **Options – letter grade (A/B/C/D…), Pass/Fail**

20% - Class participation (attendance, brainstorming sessions, report-outs)
20% - Short-answer assignments given throughout the course
20% - Short interim presentations / memos
20% - Final presentation
20% - Final report

Note: assignments may be adjusted depending on the specific interests of the teams and outcomes of in-class and homework activities.

COVID: This course is designed for in-person attendance & participation, with some amount of individual and group work for each session. As per UM policy, students are expected to be fully vaccinated against COVID-19. In instances of illness / symptoms, as well as rapid rises in community infection and hospitalization numbers may warrant individual absences, and even the entire class having to be held remotely. Absences due to illness / symptoms / positive COVID tests are allowed with prior notice. Please notify me of your absence ahead of time.

Disabilities: For appropriate accommodations to be made for students with disabilities, these students MUST register with the University Office of Services for Students with Disabilities. The OSSD is located at: G-664 Haven Hall, South State Street. Tel: 734-763-3000.
Web: www.umich.edu/~sswd/

Honor Code: The Engineering Honor Code will apply to activities of this class:

ossa.engin.umich.edu/wp-content/uploads/sites/212/2015/04/Honor-code-pamphlet-Adobe-Prof.pdf
"As an Engineer, I will participate in none but honest enterprise. To him/her that has engaged my services, an employer or client, I will give the utmost of performance and fidelity. [...] To my fellows, I pledge, in the same full measure I ask of them, integrity and fair dealing, tolerance and respect, and devotion to the standards and the dignity of our profession." Also: "He/She [the Engineer] will not injure maliciously the professional reputation, prospects, or practice of another Engineer. However, if he/she has proof that another Engineer has been unethical, illegal, or unfair in his practice, he/she should so advise the proper authority. He/she will not compete unfairly with another Engineer."

Calendar: Please refer to the sequence on Page 3 of this Syllabus as a starting point. Additional info regarding topics, assigned / suggested reading and viewing, exercises, etc., will be provided as the weeks progress, with some adjustment to the schedule and topics.