

# **HISTORICAL PERSPECTIVE**

## **The Interplay Between Education, Research, Innovation and Entrepreneurship**

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# The early university

6<sup>th</sup> Century onward: Cathedral Schools – established by the church to provide educated clergy

-----→Medieval Universities

1088----*Universitas Magistrorum et Scholarium*  
(Community of Teachers and Scholars) -----*University of Bologna*



The first Institutions considered to be universities were established in Italy, France, Spain and England in the late 11<sup>th</sup> and 12<sup>th</sup> centuries for the study of arts, law, medicine and theology.

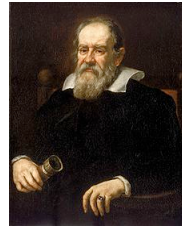
# Renaissance

## Founders of Scientific Thinking

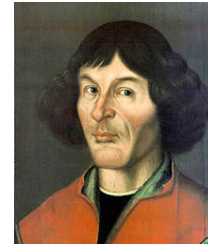
14<sup>th</sup> century-17<sup>th</sup> century Renaissance  
The contributions of *Polymaths*



Michelangelo (1475-1564)



Galileo Galilei (1464-1642)



Nicolaus Copernicus (1473 – 1543)



Leonardo Da Vinci  
1452 –1519



Andreas Vesalius (1514 – 1564)

[Nicolaus Copernicus, \*De revolutionibus orbium coelestium\* 1543 \(On the Revolutions of the Celestial Spheres\),](#)

[Andreas Vesalius' \*De humani corporis fabrica\* \(On the Fabric of the Human body\). 1543.](#)



# Renaissance



14<sup>th</sup> century-17<sup>th</sup> century Renaissance  
The contributions of *Artisans*

**1439-** [Johannes Gutenberg](#) (1400-1468) German blacksmith, goldsmith, printer and publisher . Inventor of the [printing press](#), (movable type printing 1439 )

**1590** — Two Dutch eye glass makers, Zaccharias Janssen and son Hans Janssen experimented with multiple lenses placed in a tube. The Janssens observed that viewed objects in front of the tube appeared greatly enlarged, creating both the forerunner of the compound microscope and the [telescope](#).

**1674** – [Anton van Leeuwenhoek](#) built a simple microscope with only one lens to examine blood, yeast, insects and many other tiny objects

# Scientific Revolution

- Begun toward the end of Renaissance
- Rejection of the prevailing doctrine of ‘philosophy basis of phenomena explanation’
- Introduction of Scientific Methods ..Systematic observation, measurement, experiment...
- Hypotheses and theories are tested against observation ... Empiricism
- Science becomes methodologically empirical

# Research

Research:

1570s, "act of searching closely," from M.Fr. *recerche* (1530s), from O.Fr. *recercher* "seek out, search closely," from *re-*, intensive prefix, + *cercher* "to seek for" (see [search](#)). Meaning "scientific inquiry" is first attested 1630s.

[innovate](#) 

1540s, from L. *innovatus*, pp. of *innovare* "to renew or change," from *in-* "into" + *novus* "new" (see [new](#)).

# University education in the 16<sup>th</sup> Century



1624 Statute of Monopolies (England)

1790 US Patent Act

1810 [Wilhelm von Humboldt](#)

Humboldtian university model: the goal was to demonstrate the process of the discovery of knowledge and to teach students to “take account of fundamental laws of science in all their thinking.”

Seminars and laboratories started to evolve...

Humboldt envisioned the university education as a student-centered activity of research

# Developments in the US (1<sup>st</sup> REVOLUTION)



USA: FERTILE GROUND for the Humboldtian model

1866: Boston Tech

1870: Stevens Institute of Technology

1876 Johns Hopkins University

Basic Vs Applied Research

1876 Thomas Alva Edison Laboratory 10 years- 500 patents

General Electric in 1892

Du Pont in 1902

Goodyear in 1908

General Motors in 1911

Eastman Kodak in 1912.



# Developments in the US



1925 ----University of Wisconsin.

1925-1950 Universities start adopting formal patent policies

Second WW Turning Point in University Research...  
Government Funding

1950-1960---NSF, ONR, NIH

1980 - Bayh-Dole Act permits universities to own IP  
resulting from federally funded programs

# The Present

## In 2011

- U.S. academic institutions spent \$65 billion on R&D
- Higher education sector continues to account for the majority of basic research performed in the United States.
- Academic performers are estimated to account for:
  - 55% of U.S. basic research,
  - 32% of total (basic plus applied) research, and
  - 15.2% of all R&D (\$428 billion)

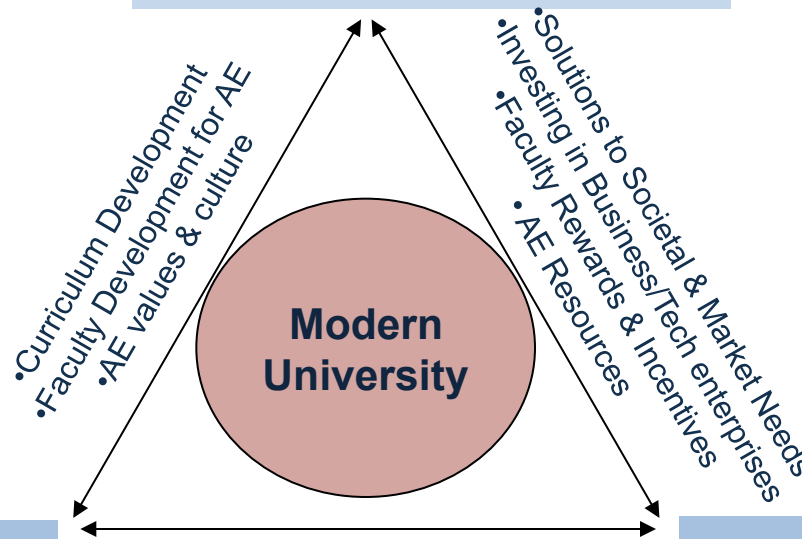
## Academic R&D

- Federal government provided 63% (\$41 billion)
- State and local government 5.9% (\$3.8 billion)
- Industry 4.8% ( \$3.1 billion ) of funding for academic R&D expenditures

# ACADEMIC ENTREPRENEURSHIP (2<sup>nd</sup> REVOLUTION)

## 1980 Bayh-Dole Act

- Knowledge Exploitation
  - Contribution to Economic Growth
- Innovation & Entrepreneurship**



### Education

- Knowledge dissemination
- Training/apprenticeship
- Ethics/Culture

- Broad Impact Research
- Disruptive Innovation
- Doctoral Programs, Scholarships
- Research Facilities, Support Structures

### Research

- Knowledge Creation
- Technology Development

Academic entrepreneurship is more than a technology transfer process, it is a shift in academic culture that adds another dimension to higher education. It prepares the student for the Innovation Age

# The Entrepreneurial University - Commercialization



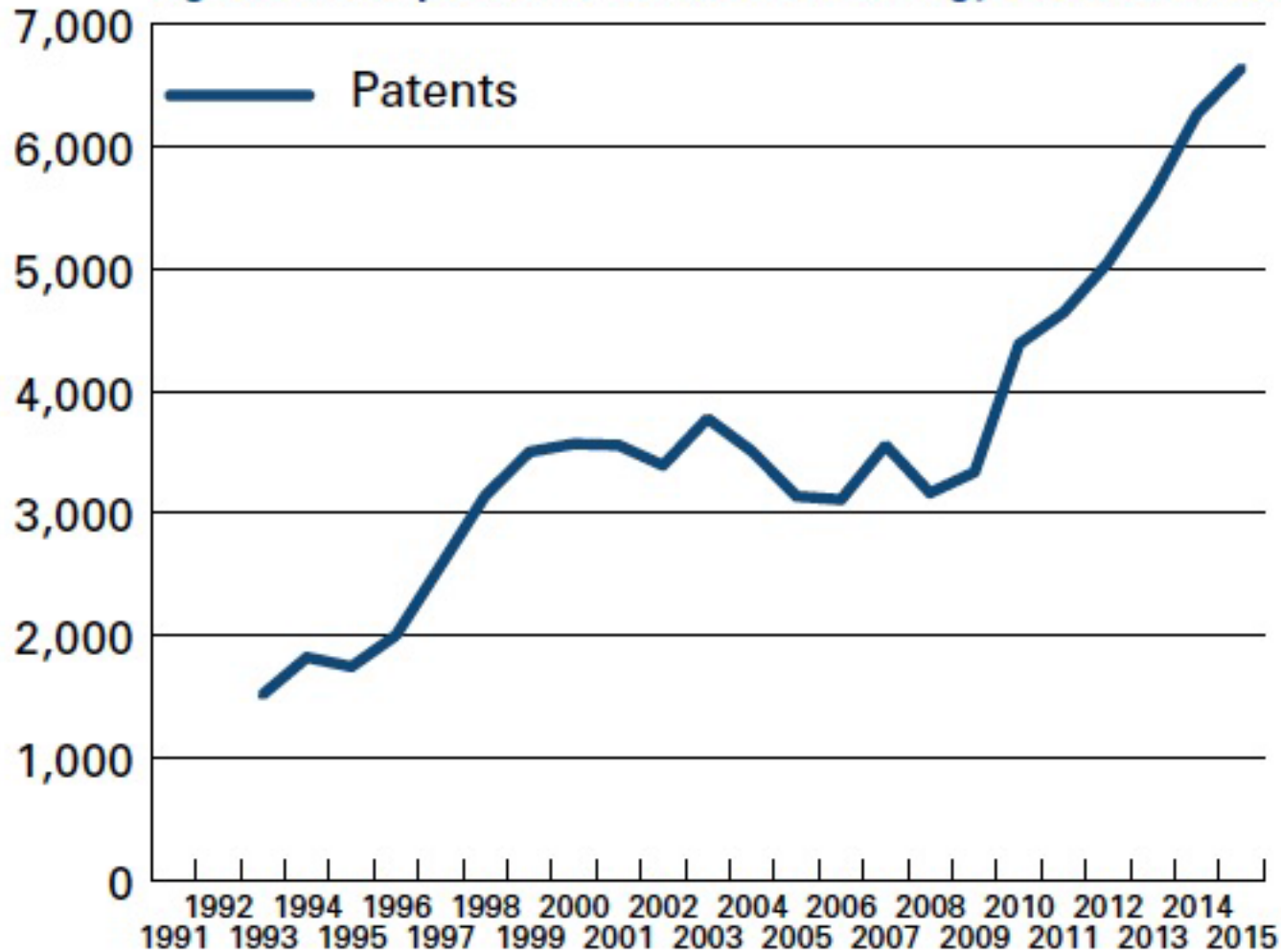
225 universities and medical research institutions reported in 2015

\$66.1 Billion spent on research for all institutions

25,272 patent disclosures;

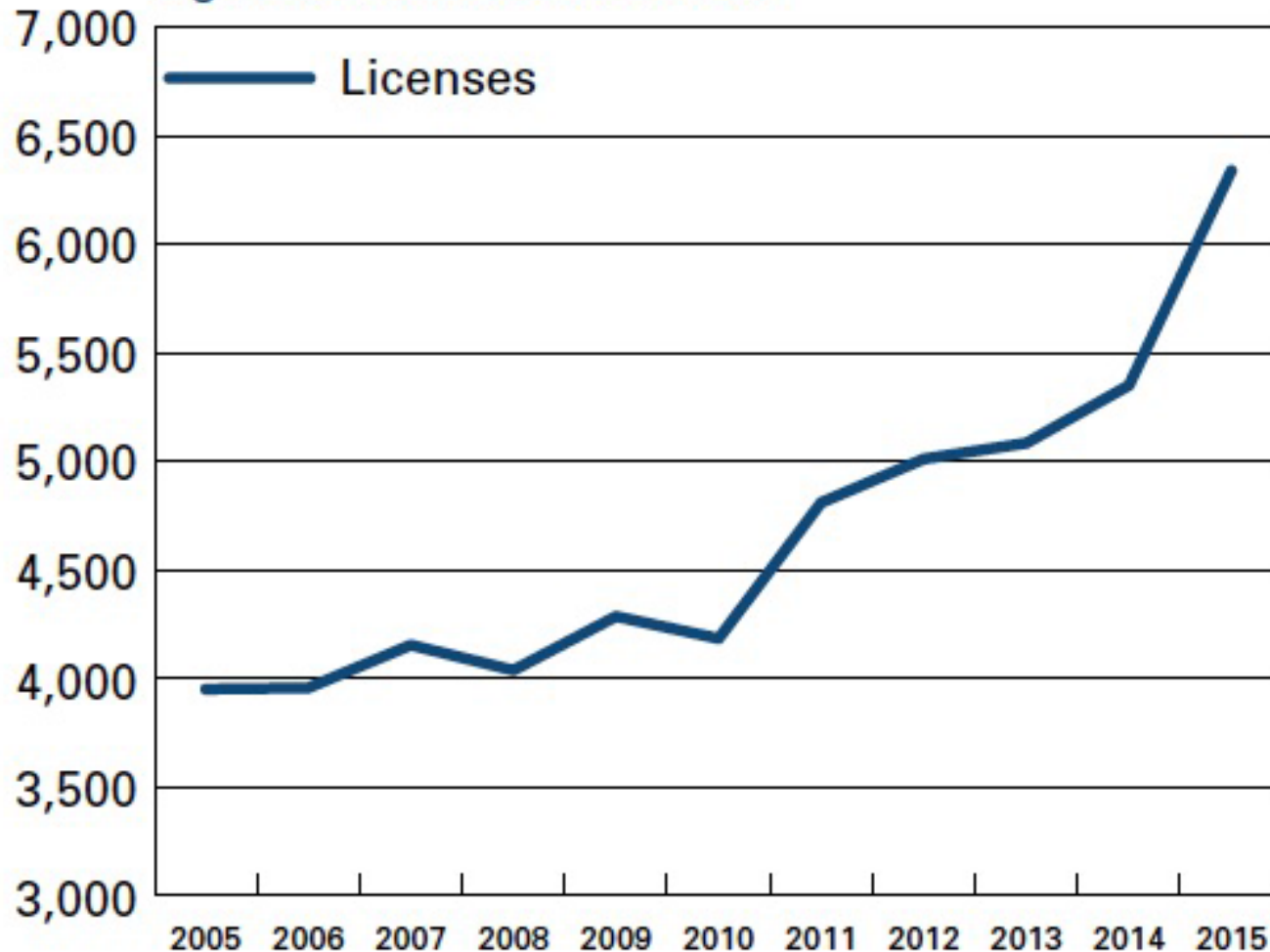
# The Entrepreneurial University - Commercialization

Figure 1: Total patents issued from technology transfer offices



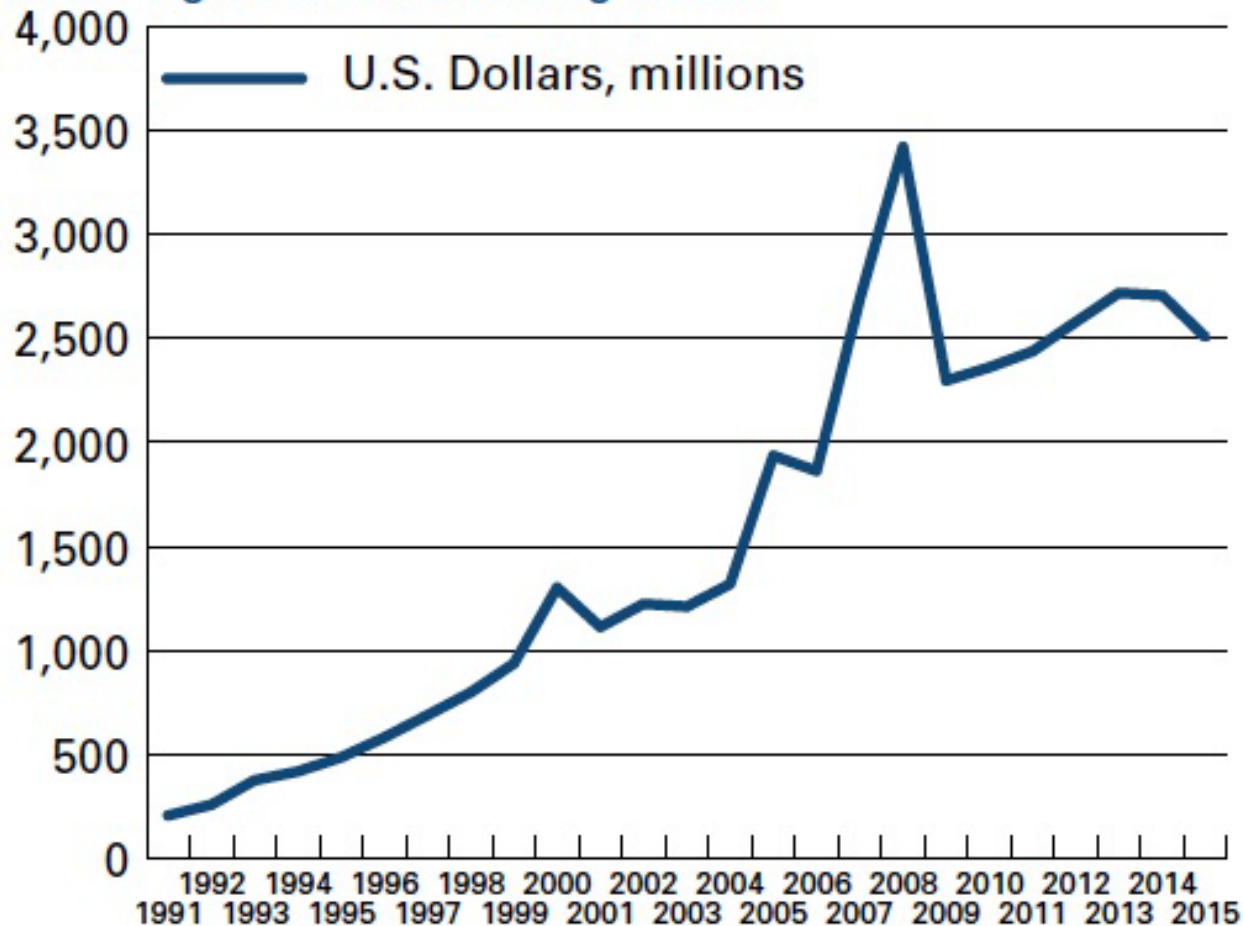
# The Entrepreneurial University - Commercialization

Figure 2: Total licenses issued



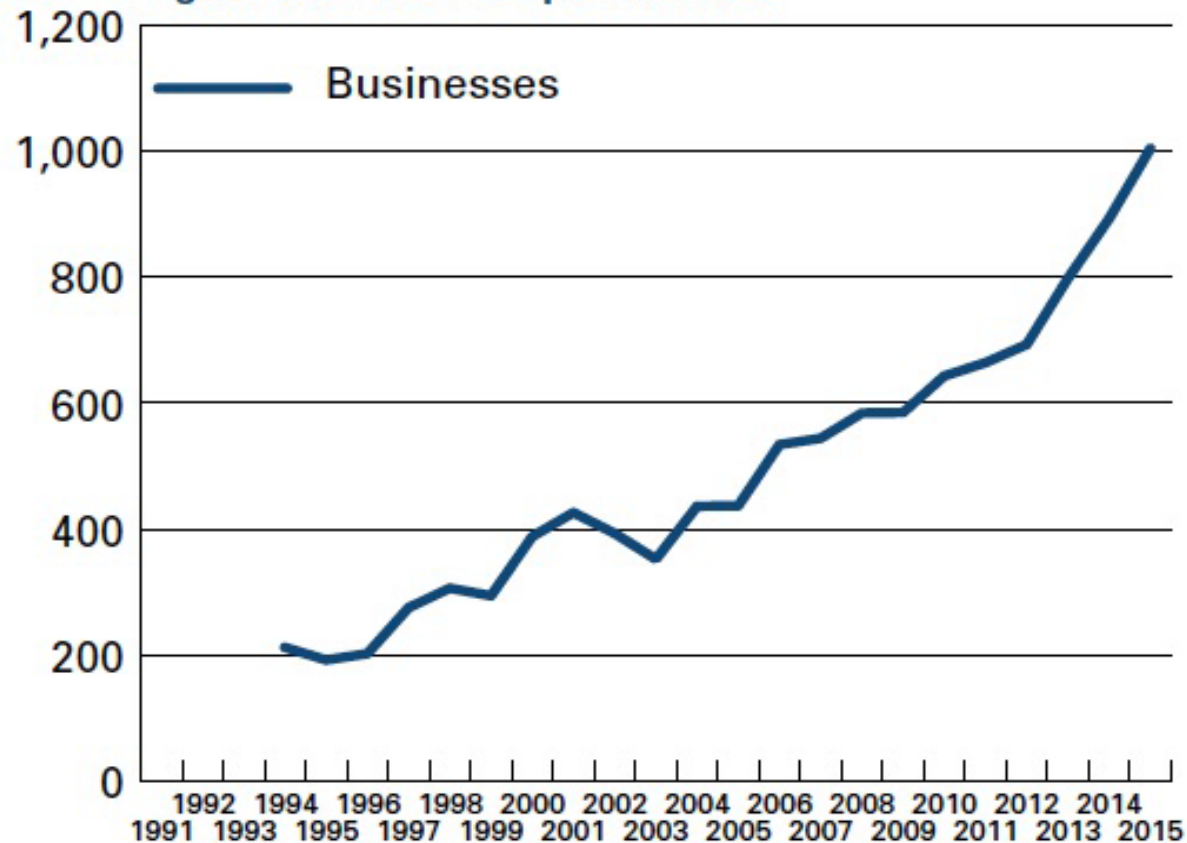
# The Entrepreneurial University - Commercialization

Figure 3: Total licensing income



# The Entrepreneurial University - Commercialization

Figure 4: Total start-ups launched





# Summary



UNIVERSITIES: Respond to Society Demands

Knowledge Age: Age of Innovation

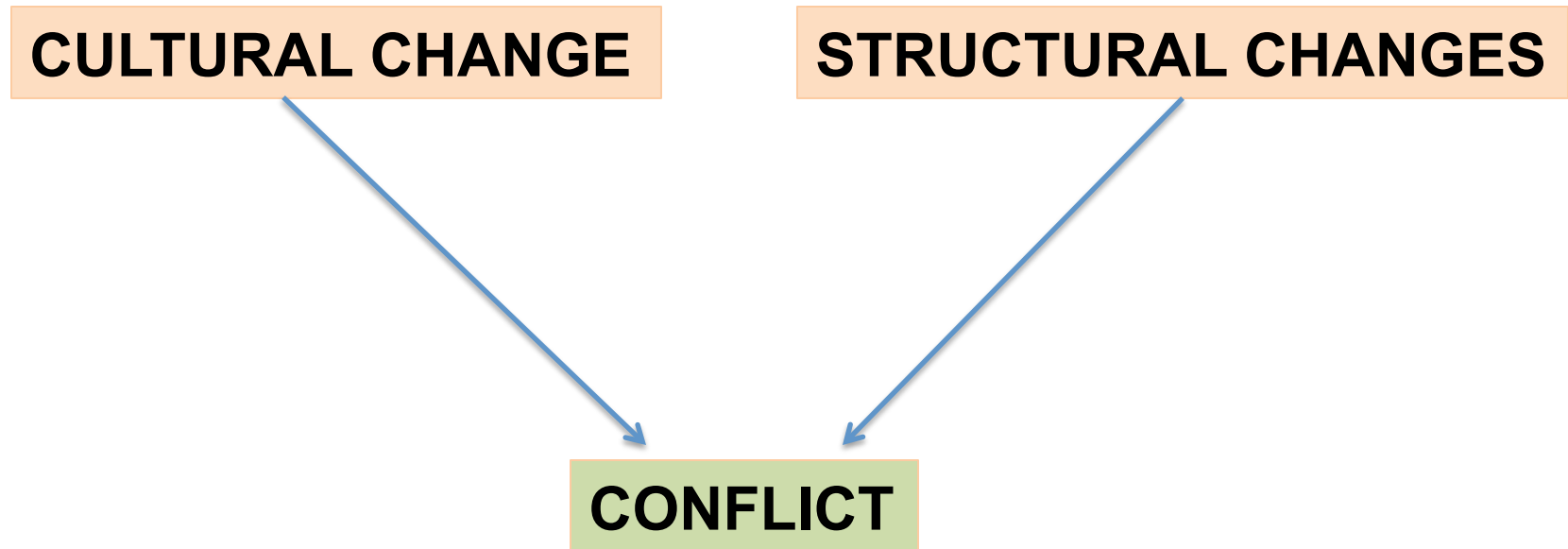
More and more universities are embracing INNOVATION and ENTREPRENEURSHIP as CORE VALUES

TEACH AND PRACTICE !!!

# EMBRACING CONFLICT

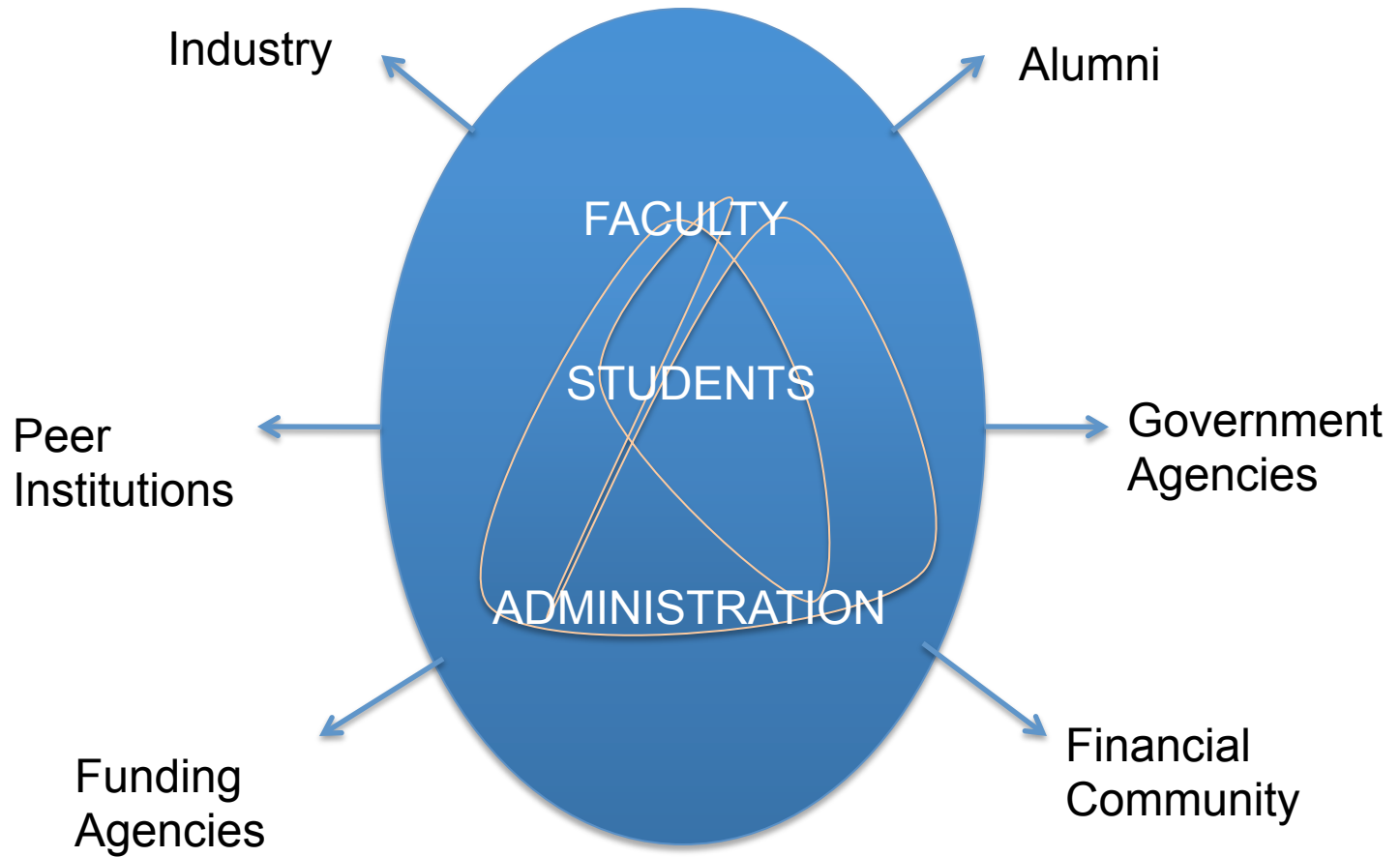
## In Academic Entrepreneurship

# Academic Entrepreneurship Leadership



**Embracing Conflict:** A Crucial Step in Achieving Cultural and Structural Change

# Stakeholders



# Conflicts

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**INTERNAL/INHERENT CONFLICTS**

**INTERFACE CONFLICTS**

# Internal Conflicts

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Research Paper Vs. Patent (faculty)

Career Path Disruption (faculty)

Faculty Incentives/Rewards (administration)

Academic Freedom (faculty/administration)

Resource Allocation -Level of Importance (administration)

Motivation-Personal Gain (faculty)

Institutional Reputation (administration)

Student IP (students/administration)

For Profit Vs. Not for Profit (administration)

# Interface Conflicts

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IP Agreements with Industry

Adverse reaction by alumni base

Acceptance by Peer Institutions

Skepticism by Financial Institutions

Confidentiality Agreements

Joint Patents

Non Traditional Business Models

# Summary

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**UNYIELDING SUSTAINED COMMITMENT BY UNIVERSITY LEADERSHIP  
(3 Layers Deep)**

**APPROPRIATE ENTERPRISE ARCHITECTURE**

**COMPETENT INFRASTRUCTURE  
(Treat Innovation and Entrepreneurship as the third CORE ENTERPRISE)**

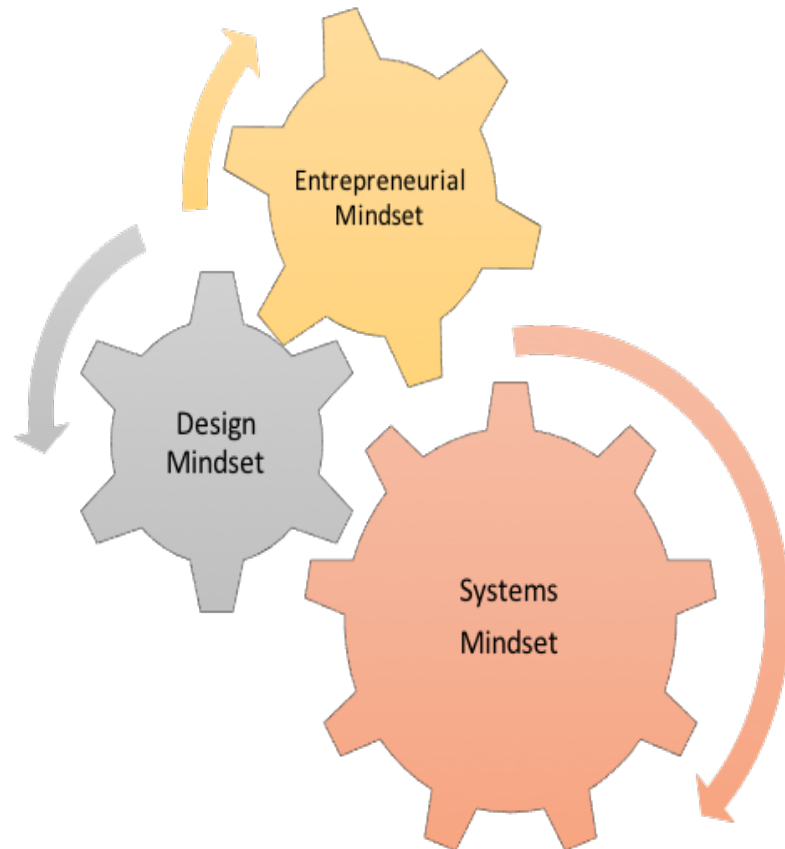
**POLICIES AND GUIDELINES THAT ARE WELL THOUGHT OUT**

**EFFECTIVE AND SUSTAINED COMMUNICATION**

**PRACTICE NOT ONLY TEACH**



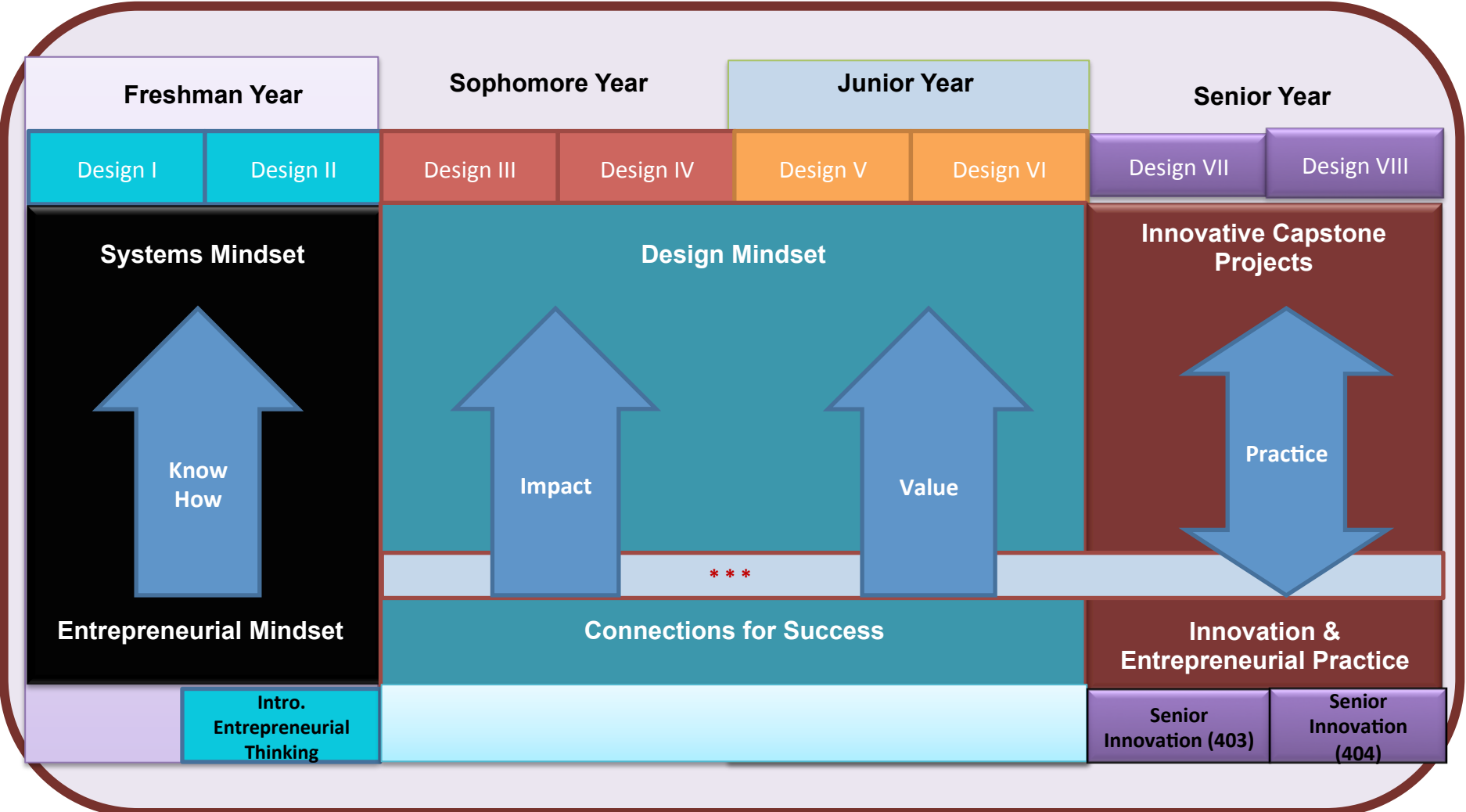
# Evolution of Systems, Design and Entrepreneurial Mindsets in Engineering Education

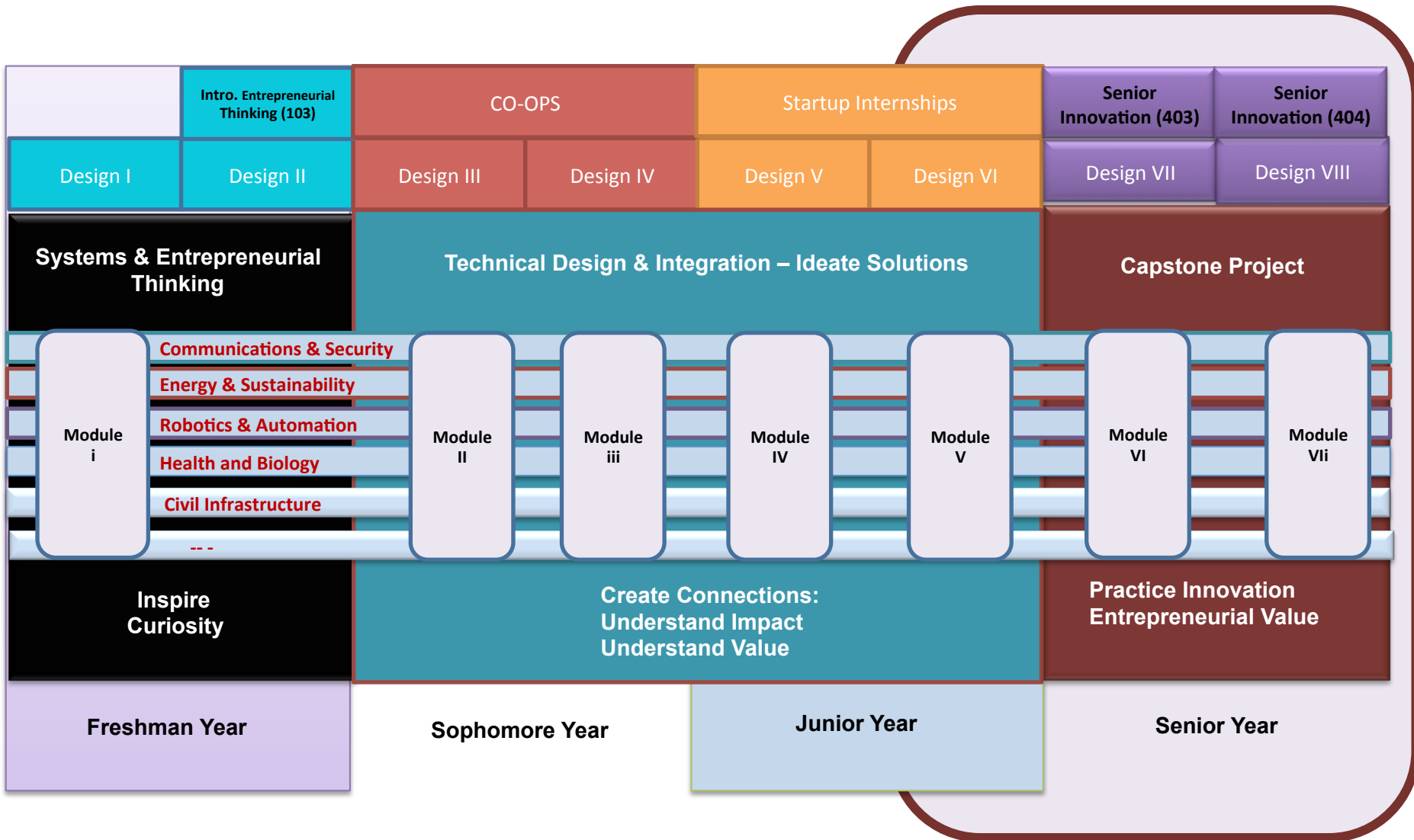


**These mindsets work together and so must be developed together**

- **Systems Mindset:** Systems-first approaches and design processes with stakeholder, system needs, requirements and interfaces considered early on in design cycles
- **Design Mindset:** Comprehensive design thinking mindful of impact and value during composition of technical solutions
- **Entrepreneurial Mindset:** Awareness of customer, market, business and societal values; preparation to manage technology, risk, finances and human resources in a early stage business

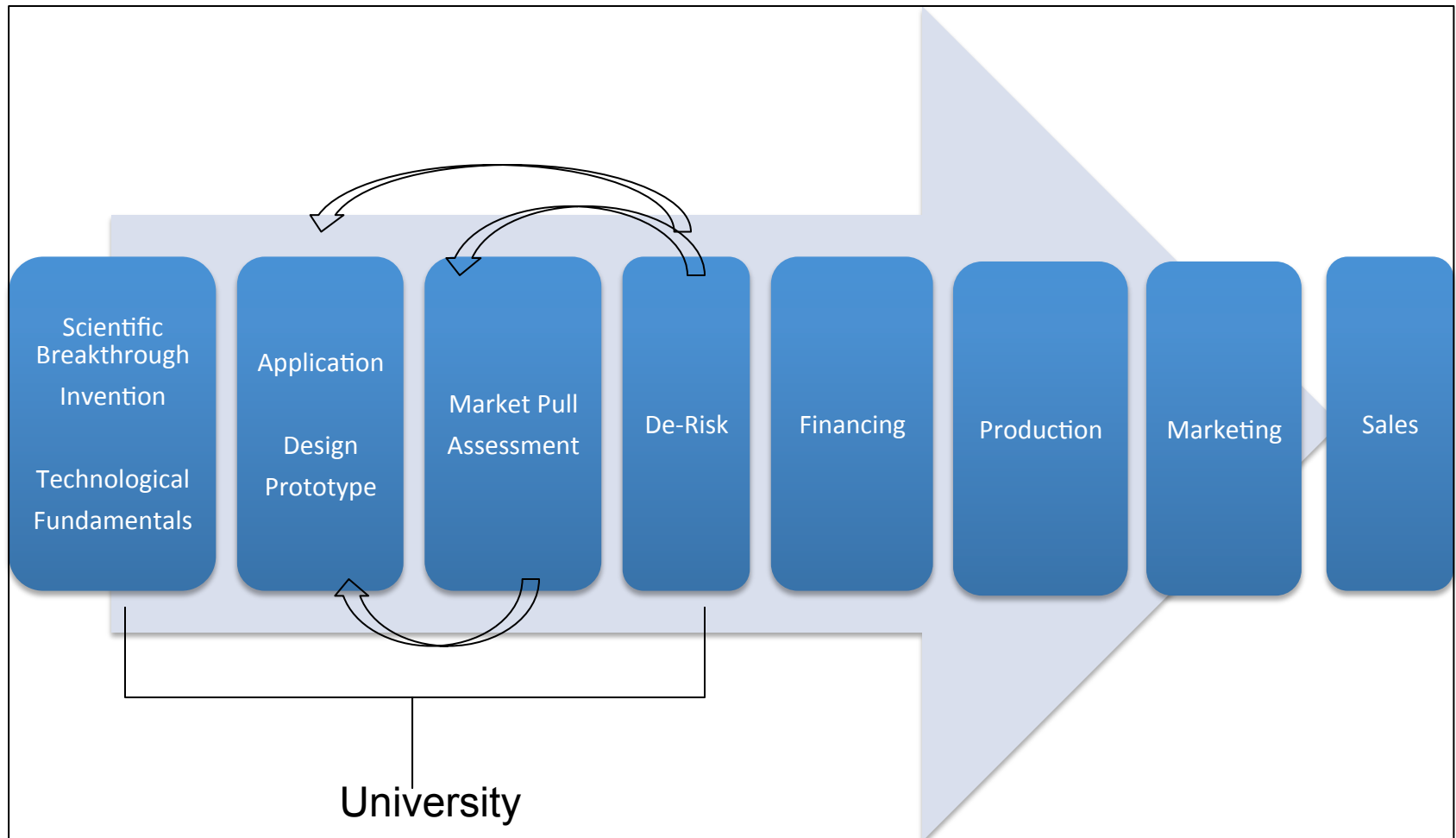
# Current Model for Entrepreneurial Thinking within Stevens Curriculum





# THE PATH TO TECHNOLOGICAL ENTREPRENEURSHIP

## Basis: Science and Engineering



When is the right time to spin out a start-up company?

Thank you!!

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## ABSTRACT

### THE INETRPLAY BETWEEN EDUCATION, RESEARCH, INNOVATION AND ENTREPRENEURSHIP

**This presentation examines the evolution of technological innovation and entrepreneurship within the university throughout history. It starts with the early formative years of the university as an enterprise of higher learning and concludes with the modern university and the adoption of innovation and entrepreneurship as a core element of the university mission. During the Renaissance period inventions and their introduction to application was done by polymaths like da Vinci who provided the fundamental vision and foundational knowledge, and artisans like glassmaker Anton van Leeuwenhoek the inventor of the microscope. Such inventions were largely independent of the university which was a place responsible only for knowledge transmission. As the scientific revolution followed, the scientific methods of systematic observation and experimentation established research as a tool for technological innovation and was quickly adopted as the second core element of the university mission. It is worth noting that the introduction of research into the mission of the university came with great negative reaction by the academic community. The debate centered around the concept that the results of university applied research funded by industry will be tainted.**

**Universities in the USA begin to realize the value of the intellectual property created by faculty and student research in the beginning of the 20<sup>th</sup> century despite the negative reactions of many members of the academic community. The Bayh-Dole Act of 1980 allows universities to own intellectual property that results from research. This causes universities to pay more attention to the intellectual property they create and develop initiatives to exploit its value. Over the past 25 years universities have developed technology transfer offices in order to commercialize their intellectual property. Like any other disruptive change this has brought many conflicts that universities have tried to manage. Innovation and entrepreneurship is becoming a core objective of universities around the world. Most of the IP created is in the health care and technology sectors and this positions scientists and engineers in the forefront of innovation and economic growth. Many universities have adopted innovative and entrepreneurial thinking in their curricula programs. In addition, most research universities are providing an infrastructure of support to their students helping them to spin out start-up companies. In some universities this support extends to students after graduation.**