CDIO and Universities as Engines of Economic Development

Ed Crawley
MIT
Skoltech
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Building a CDIO Program

- CDIO is a framework of effective practices
- Great deal of flexibility
- Perfectly applicable to Skoltech - a green field graduate program
- Now applying it to MIT across the School of Engineering – a brown field
- Most useful resource is the Standards

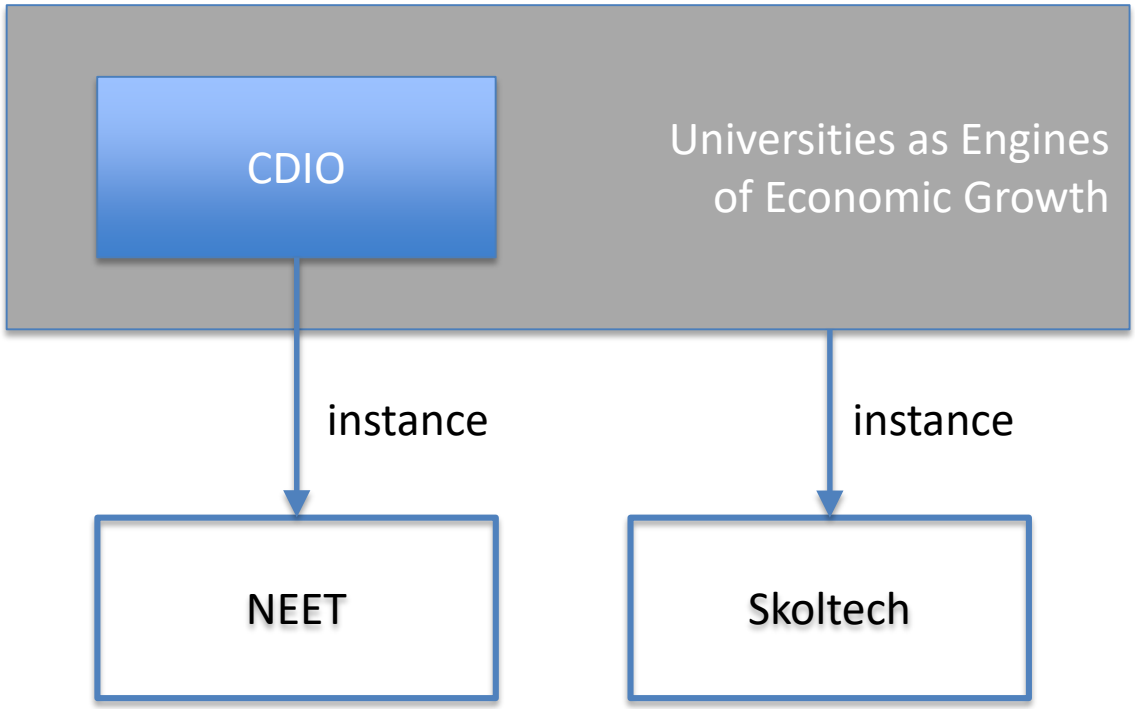
The CDIO Standards: An Effective Practice Framework

1. The Context: adopt product and system lifecycle context
2. Learning Outcomes: knowledge and skills
3. Integrated Curriculum: fundamentals with skills
4. Introduction to Engineering
5. Design-Implement Experiences
6. Engineering Workspaces
7. Integrated Learning Experiences
8. Active Learning
9. Enhancement of Faculty Competence
10. Enhancement of Faculty Teaching
11. Learning Assessment
12. Program Evaluation

Feedback on Standards

- Which is the most useful?
- Which is the most difficulty to implement?

CDIO Universities as Engines of Economic Growth



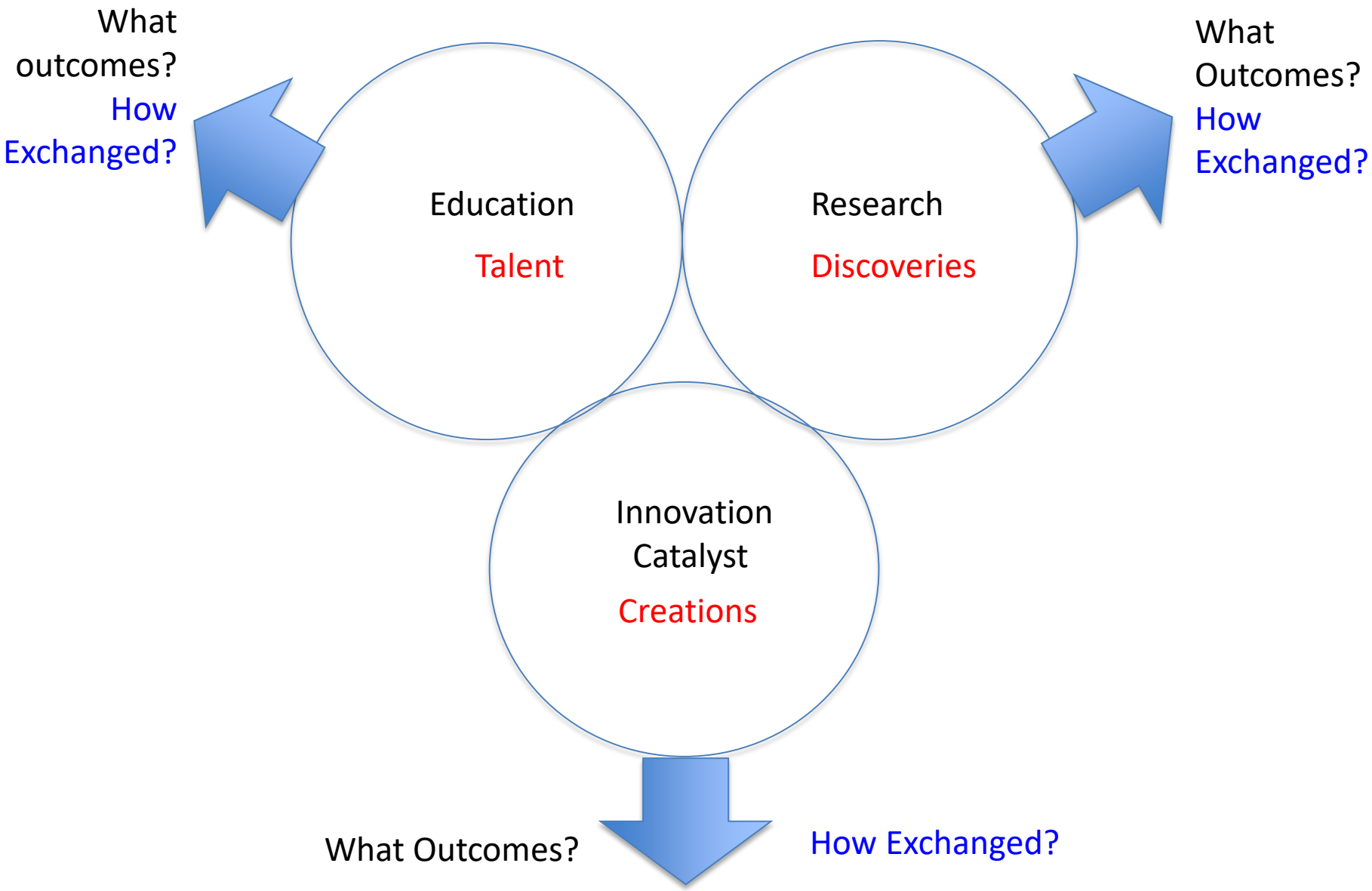
The Goal and Expectation of our Stakeholders

Hierarchy of Outcomes

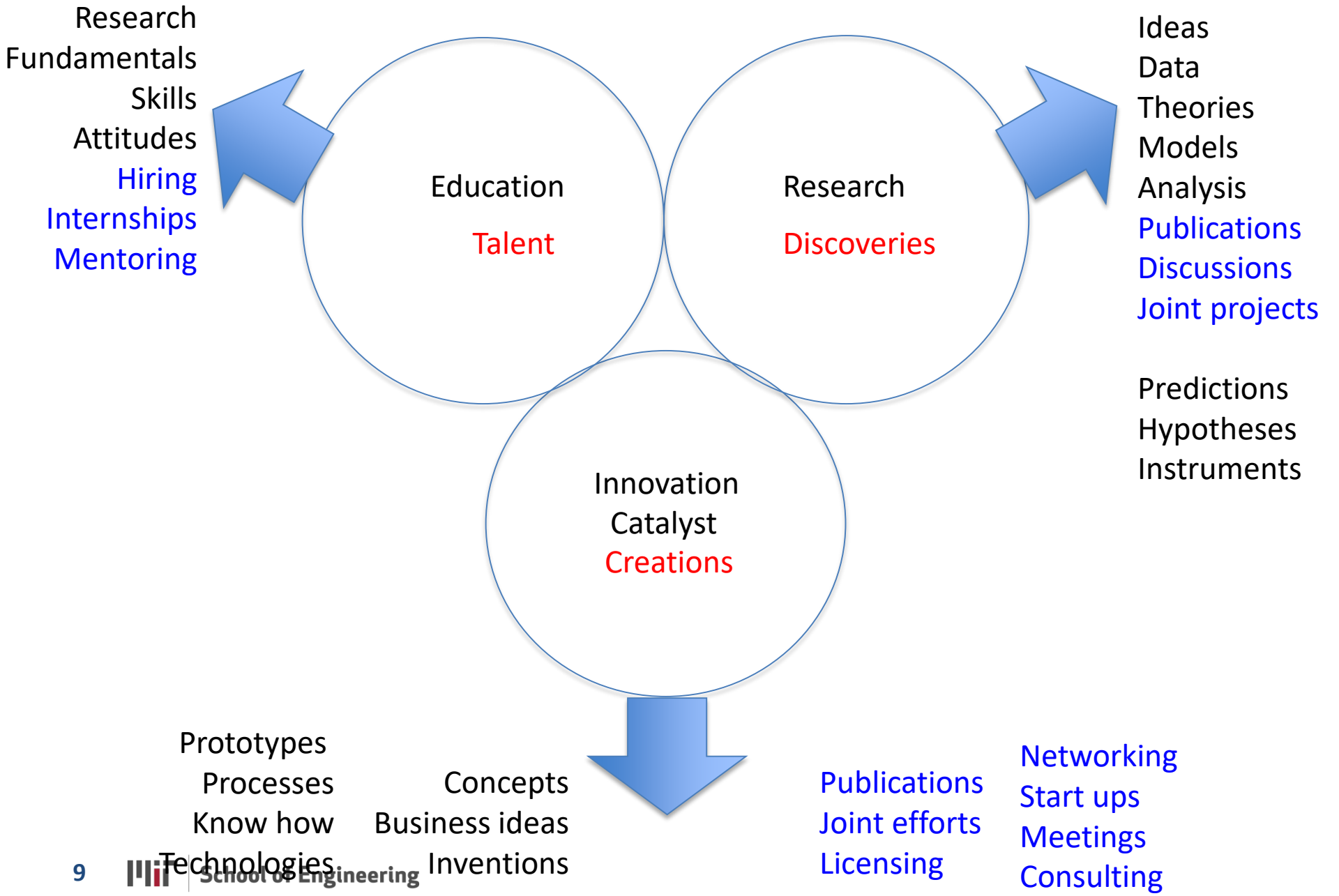
To substantially enhance knowledge exchange and accelerate innovation

By an *integrated system of activities* at a university – the constructive interplay of education *and* research *and* innovation catalyst, all engaging with industry

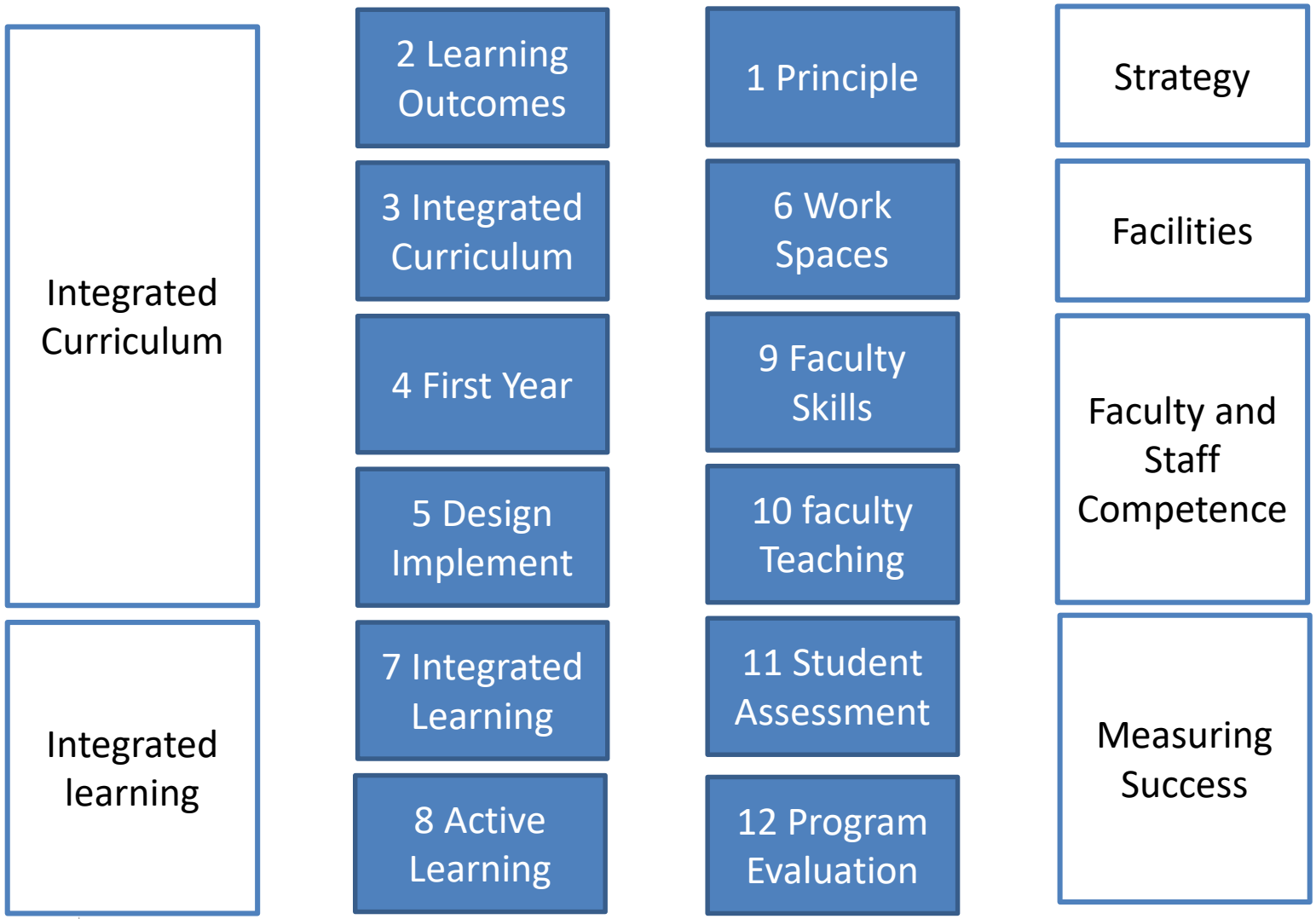
What are the Outcomes? How are they Exchanged?



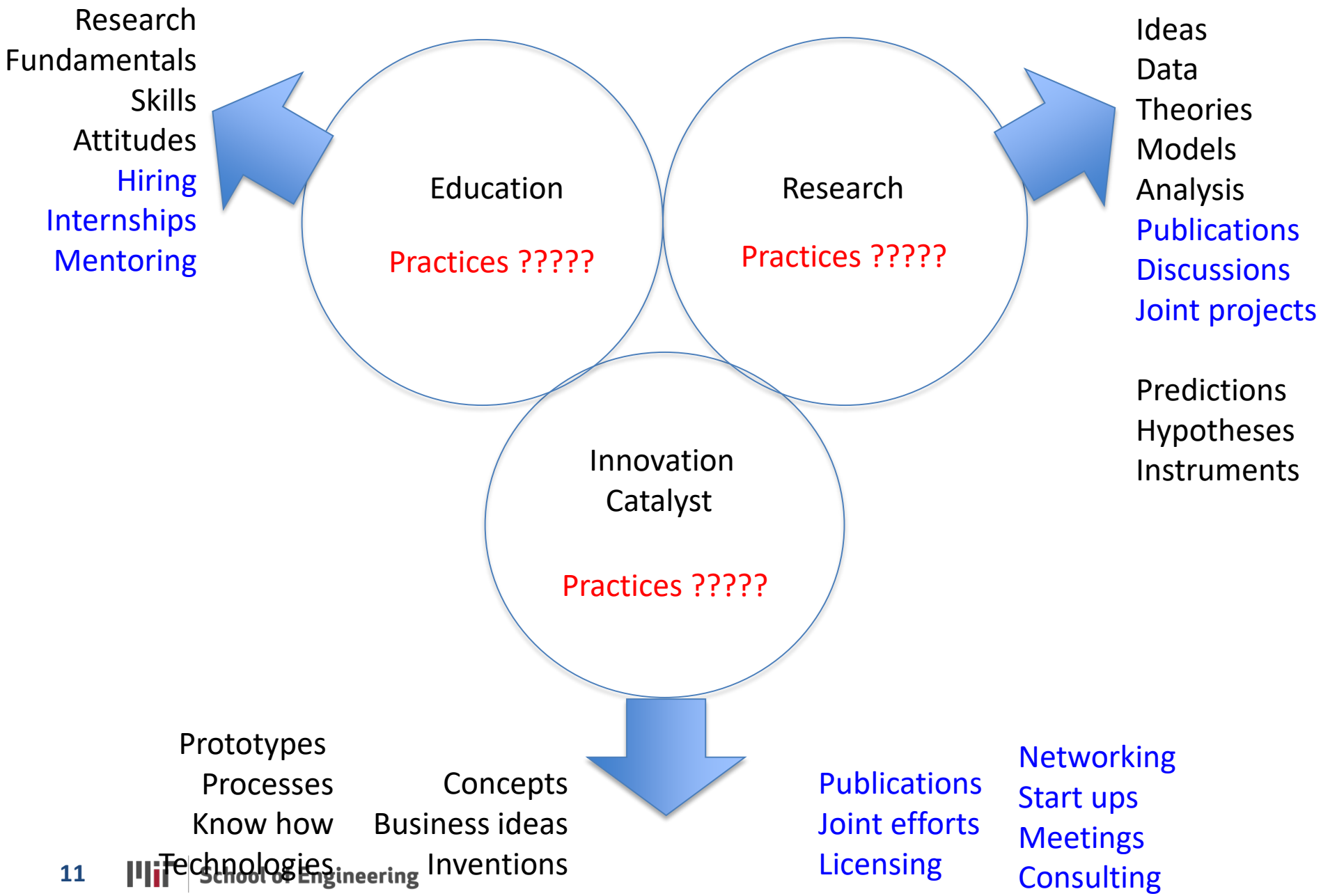
Outcomes and Knowledge Exchange



Abstracting the Standards to Effective Practices



What are the Practices?



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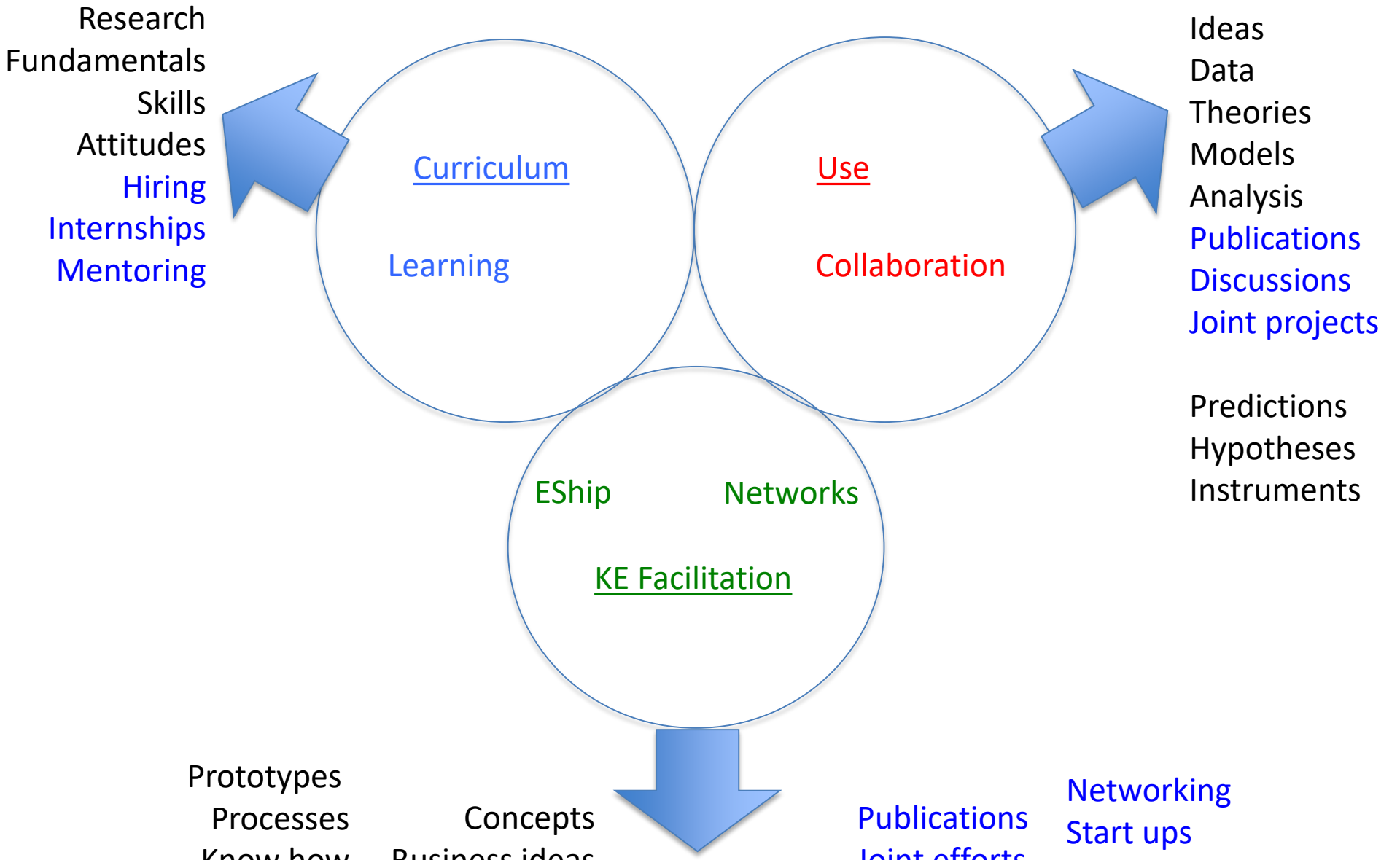
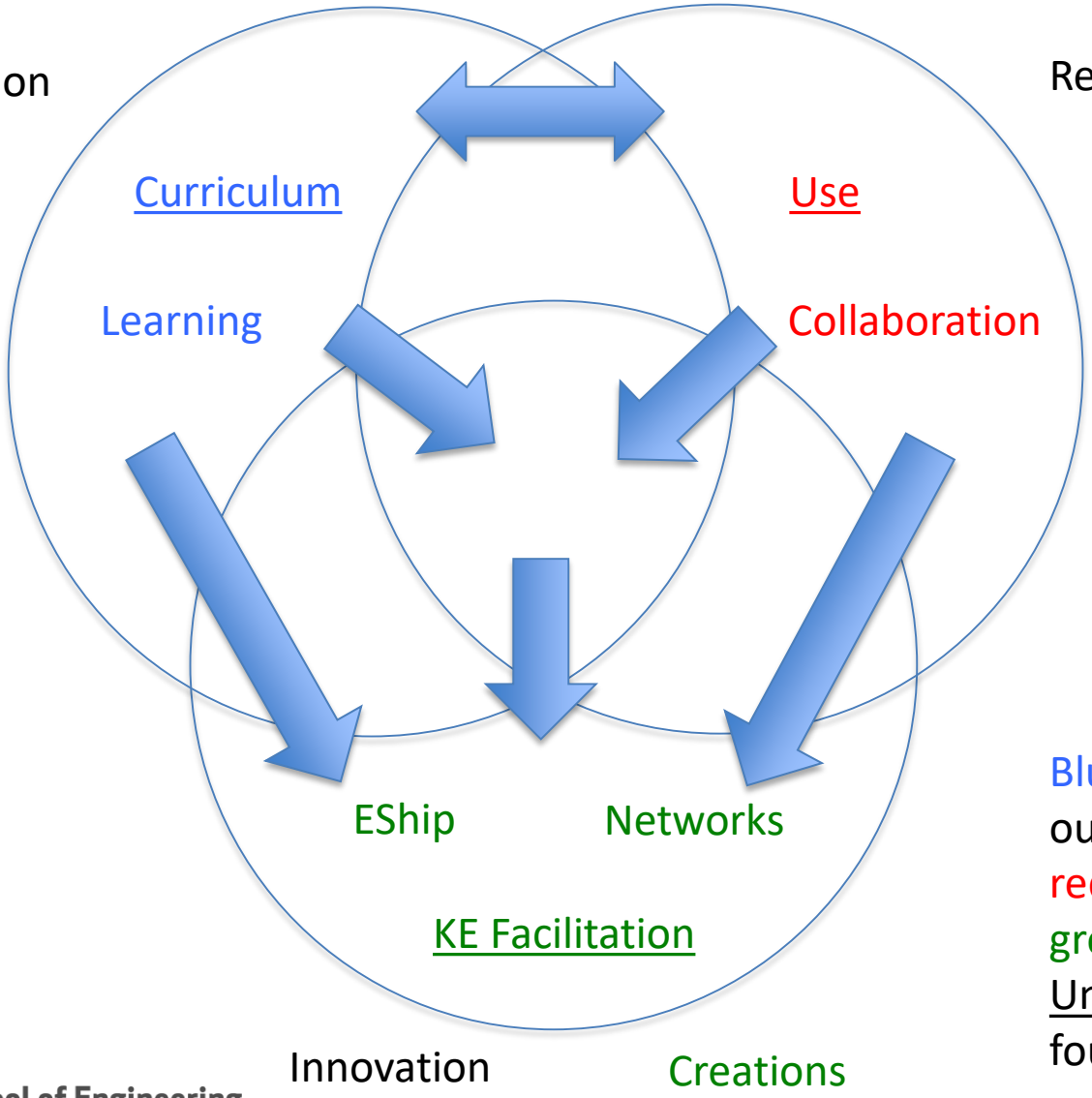
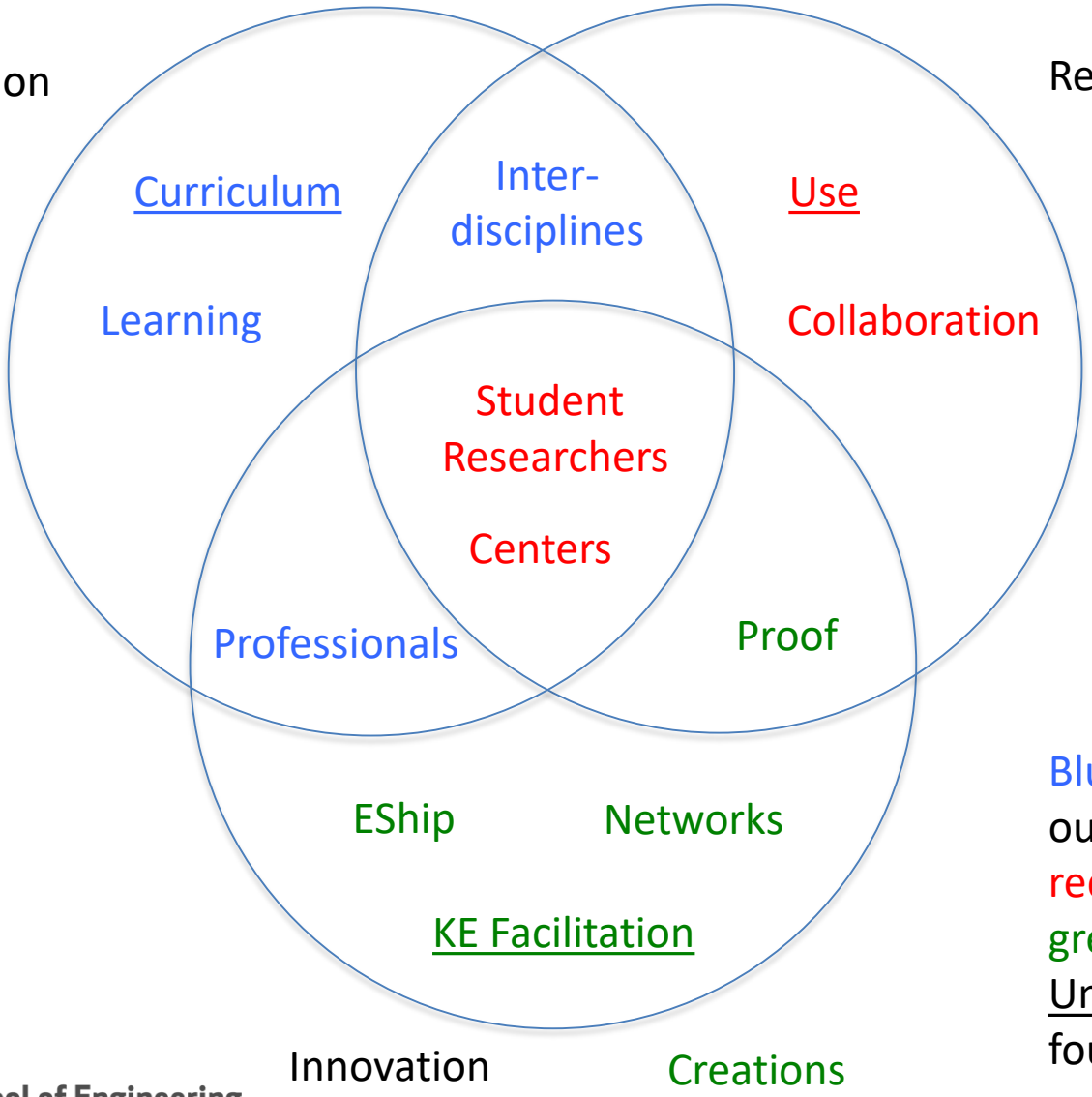


What are the Effective Practices in Overlaps



Blue has primary outcome of talent, red of discoveries, green of creations. Underlined is the foundational practice

Effective Practices



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Goals Underlying Effective Practices

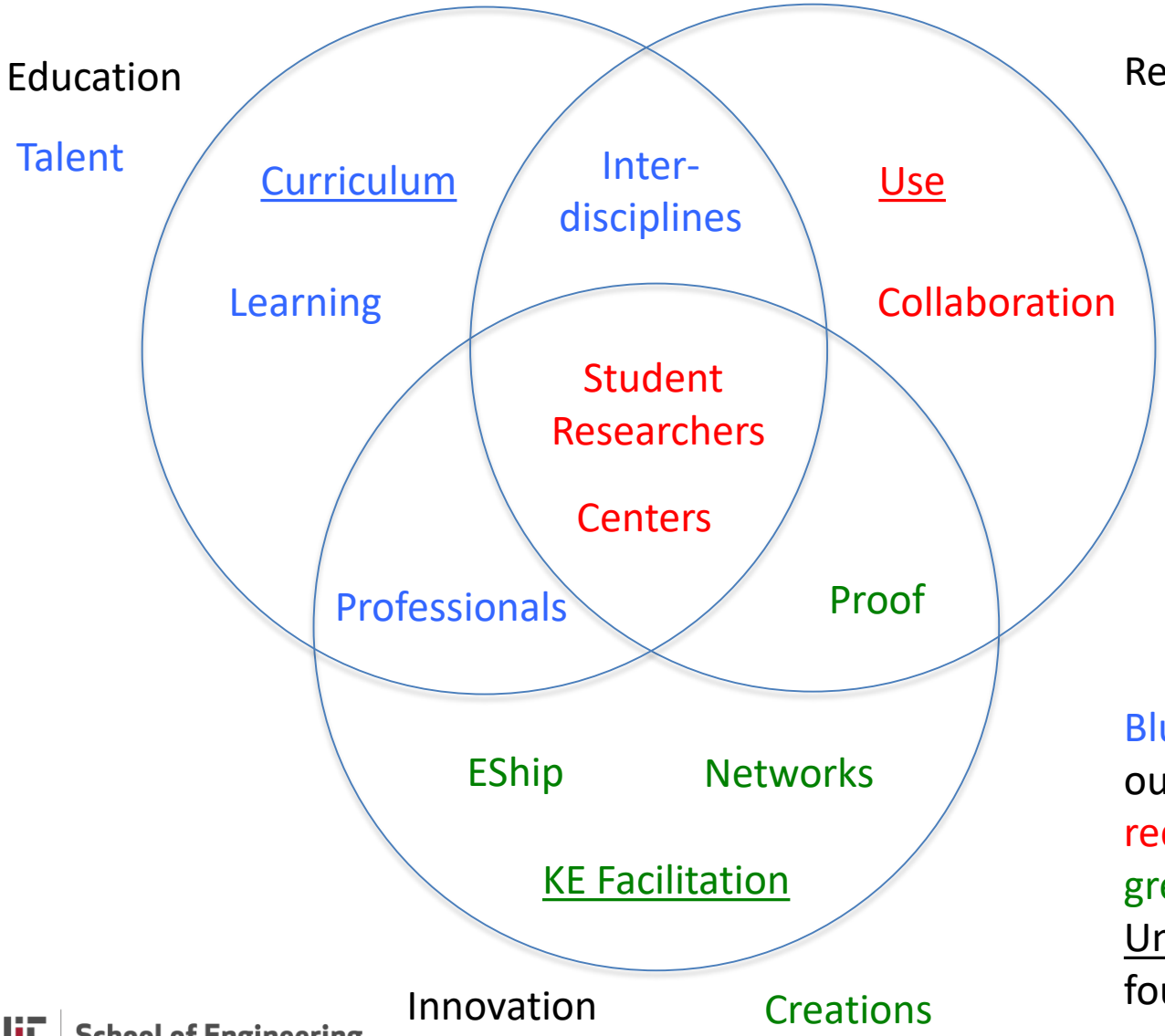
To substantially enhance knowledge exchange and accelerate innovation
By an *integrated system of activities* at a university – the constructive interplay of education *and* research *and* innovation, all engaging with industry –

To educate students with a deeper working knowledge of fundamentals while better preparing them to play roles as knowledge exchange agents, innovators and future entrepreneurs

To preserve the integrity of curiosity driven research while making research a more important instrument of innovation and knowledge exchange

To better catalyze innovation within the university and more effectively exchange knowledge with industry

Effective Practices – Skoltech has them all!



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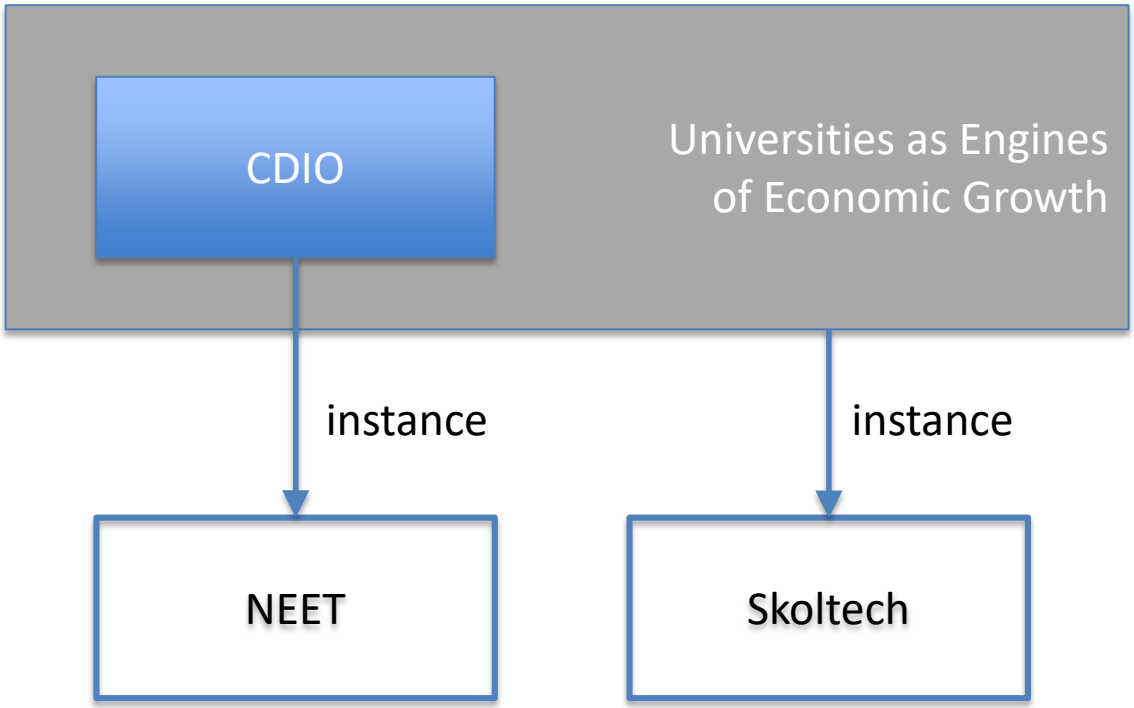
Design of Skoltech

Practice	Implementation at Skoltech
Curriculum	SH outcomes, program themes
Learning	Student engagement in learning
Inter-disciplines	Programs aimed at societal issues
Young Professionals	Innovation workshop
Research with Use	Research aimed at societal needs
Collaboration	Research teams, MIT
Students Researchers	From the very beginning
Centers	CREIs
E-Ship	Incubator, funding form Sk Foundation
KE management	Center for Innovation and Entrepreneurship
Networks	Skolkovo
Proof of concept	STRIP

CDIO Universities as Engines of Economic Growth



Principle #1 New Machines and Systems

- Our education should focus on preparing our students to develop the new machines and systems that they will be building in the middle of the 21st century.

By this we mean all of the constructs that engineers build: mechanical, informational, biological, energetic, molecular, infrastructural

Standard: ?

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Standard: 1 Context

Old Machines → New Machines

The Airplane

1950's "Old Machines"

Today's "New Machines"

Principle #2

- We should help our students to prepare themselves to be makers, discoverers or on the spectrum, and we should teach engineering fundamentals as a foundation of careers both in research and practice.

Standard: ?

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Standard: 2 Outcomes

Principle #3 – Pedagogy to Support How Our Students Learn

- We should build our education around the way our students best learn, engaging them in their learning and self learning, and implementing pilots in digital education – where we are considered a leader.
- And by supporting our faculty in the transition with the NEET academy.

Standard: ???

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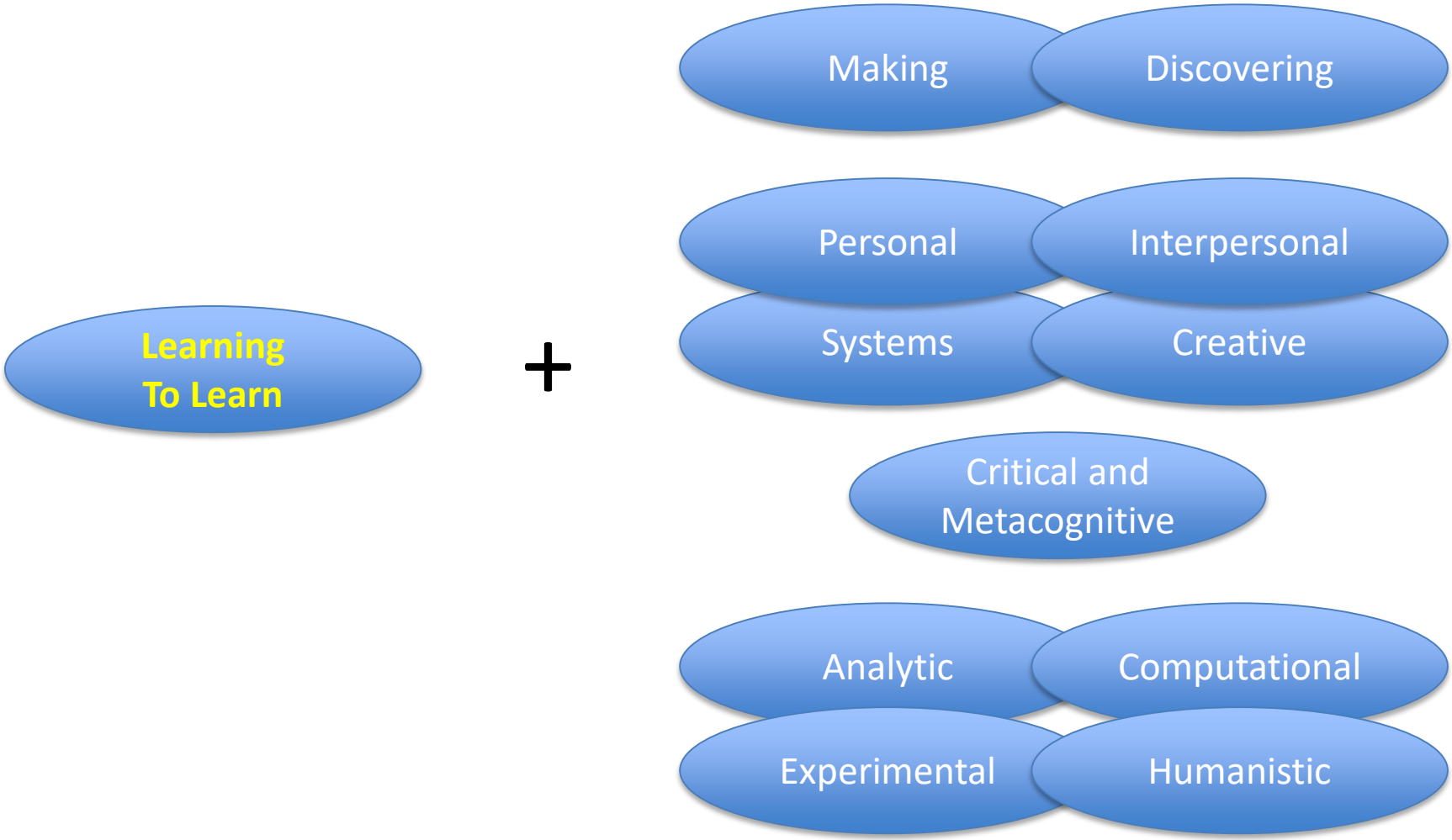
Standard: 8 Active Learning, 9 10 Faculty Skills

Principle #4 – Ways of Thinking

- In view of the speed of scientific and technological development, we should teach students how to think, and how to learn by themselves.

NEET as an Education in Ways of Thinking



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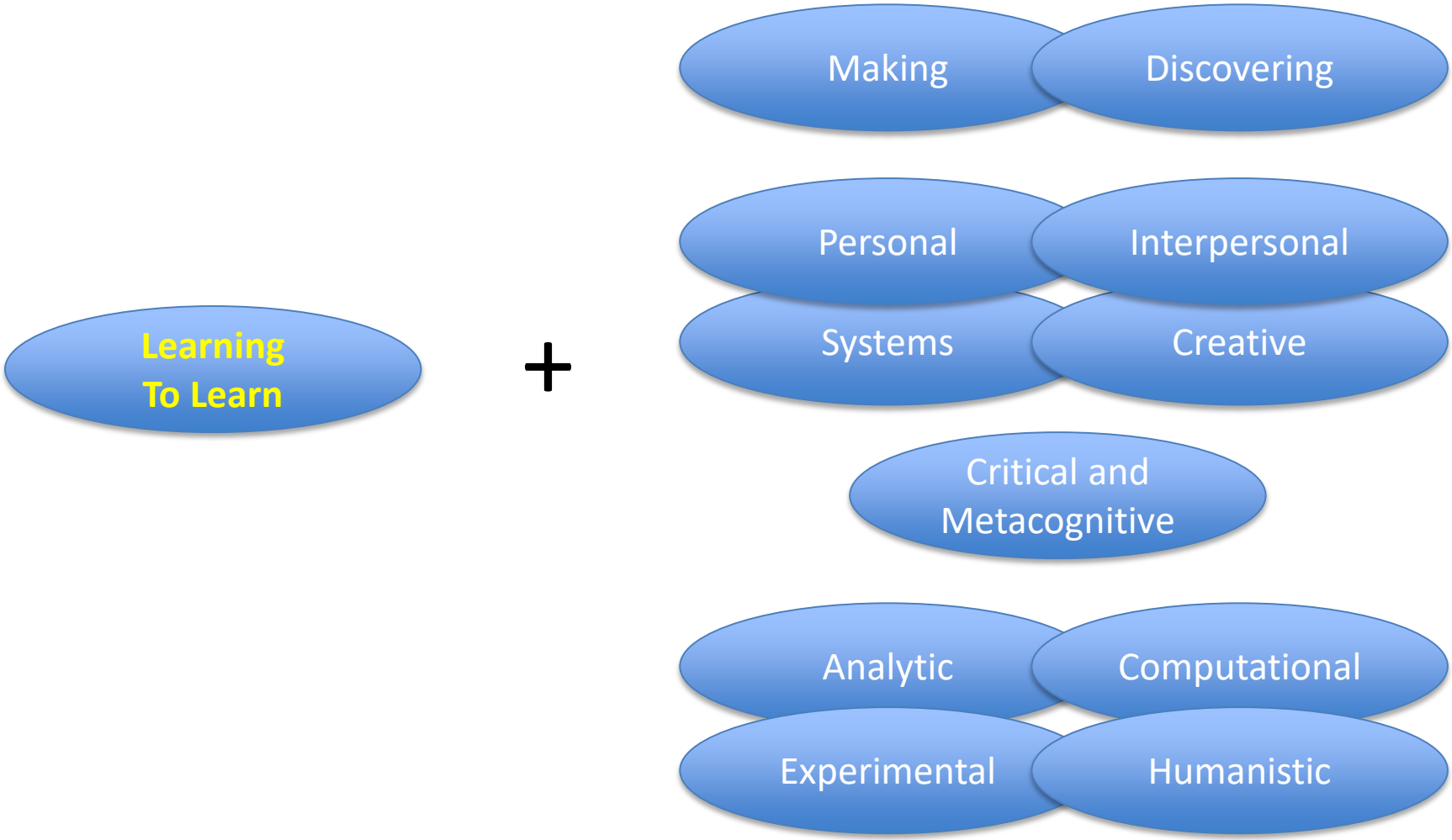
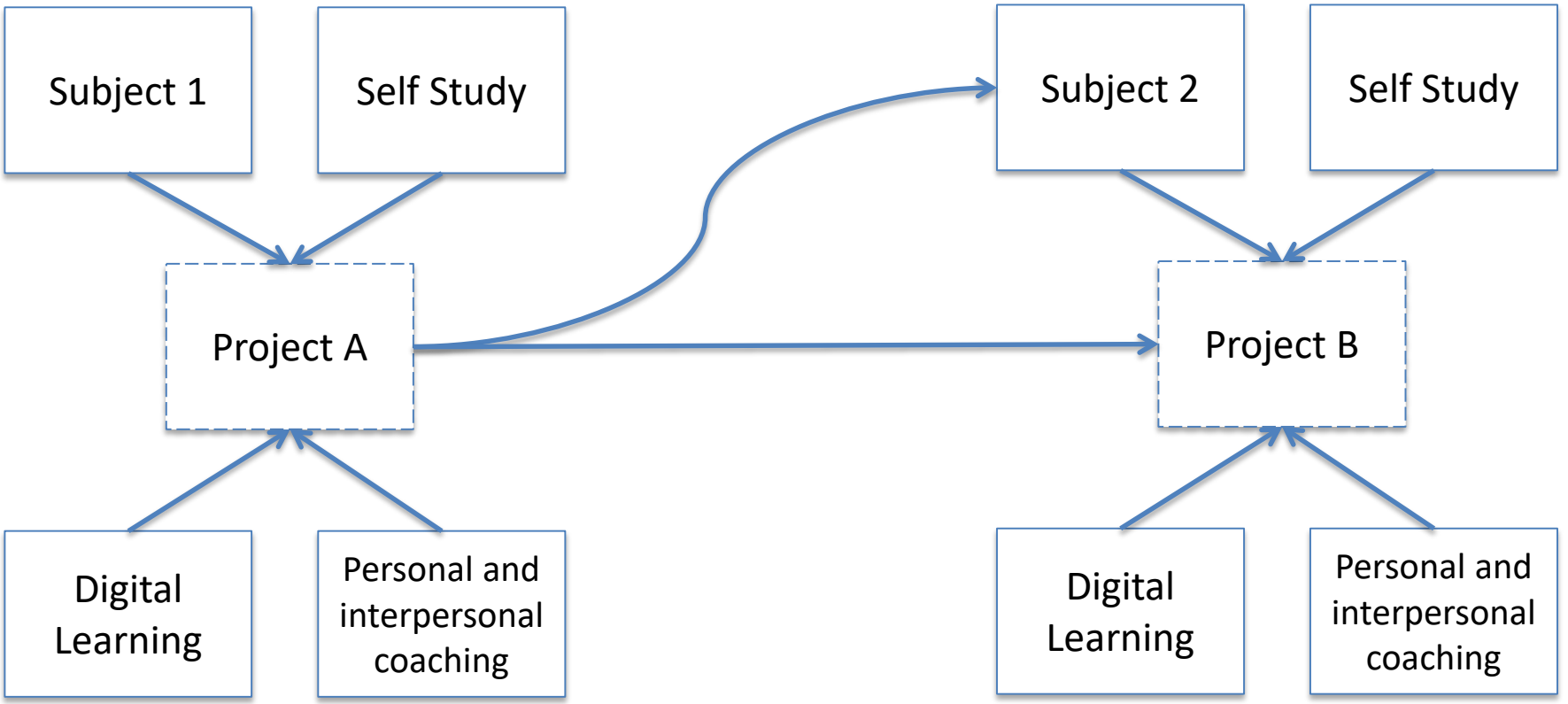


Standard: 2 Outcomes

NEET Project Centric Curricular Construct



Standard: ???

All modules also yield learning retained for life

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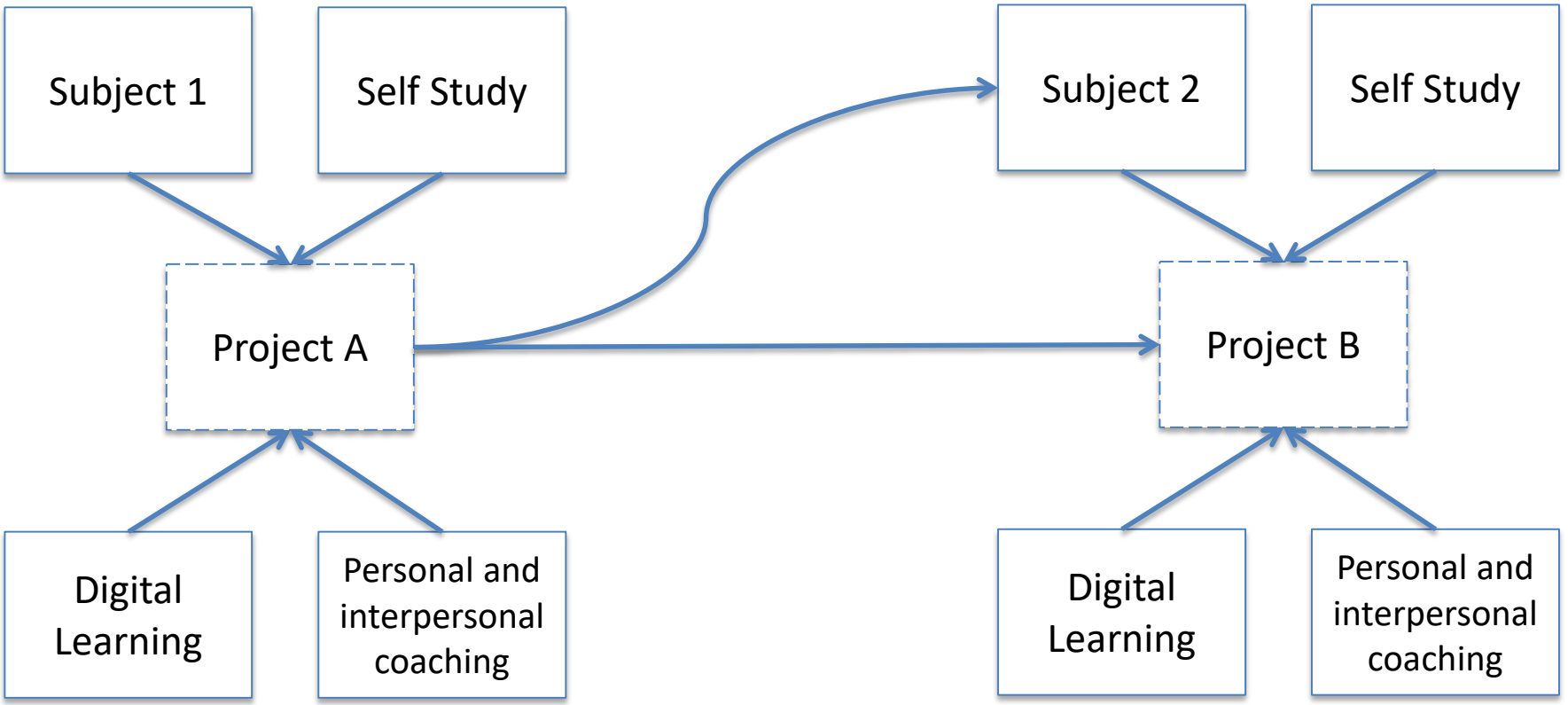


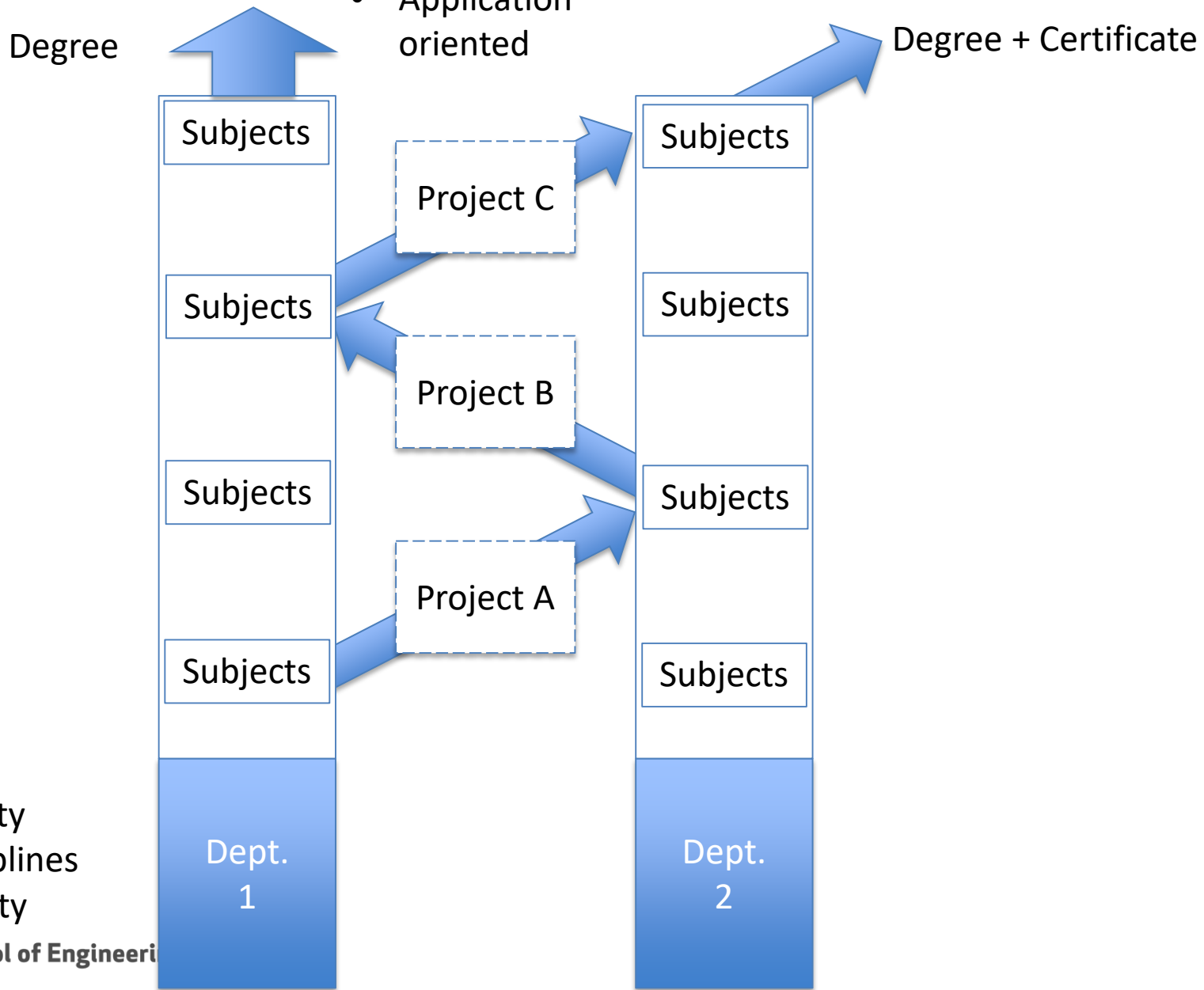
All modules also yield learning retained for life

Standard: 3 Curriculum, 5 Design Implement, 7 Integrated Learning

NEET System of Projects

	A	B	C
Interpersonal	Individual	Small group	Larger group
Context	Building on fundamentals	Implementation, operations, QC	Market and finance issues
Computation	Simple tools	Computational tools	Advanced tools
Personal	Decisions, ethics integrity	Initiative, judgment	Responsibility, flexibility
Self learning	Builds on subjects	Self study of common topics	Professional self study

- New Machine
- Interdepartmental
- Application oriented



- Faculty
- Disciplines
- Quality

Implementation of NEET

- Programs in preparation
  - Autonomous Machines (autonomy and robotics)
  - Living Machines (biomedical diagnostics and therapeutics)
- Next group of programs
  - Low Carbon Energy Machines
  - Material Machines (materials manufacturing)
  - Network Machines (networks and systems)
  - Sustainable machines (sustainable materials and energy)
- Future
  - Internet of Machines (internet of things)
  - Data Machines (Data analytics)
  - Urban Machines (Smart cities)
  - Network Machines ((networks and systems)

Thank You

Backup

CDIO

- Goals
  - To educate students to master a deeper working knowledge of the technical fundamentals
  - To educate engineers to lead in the creation and operation of new products and system
- Means
  - A set of 12 Standards in curriculum, learning and supporting practices
  - Reference materials, community

The Culture and Values of MIT

- Useful knowledge (1861) "… in industrial society, science and technology were legitimate foundations for higher knowledge…"
- Societal responsibility (1861) "… to apply the fruits of scientific discovery to the satisfaction of human wants"
- Learning by doing (1861) "… converting personal experience into knowledge."
- Education as preparation for life (1949) "… provide students with an education that better prepares engineers to function as professionals…"
- The value of fundamentals (1949) "…education should be based on the fundamental principles..."

Standard: ?

Summarized in the Task force on Student Life and Learning 1998

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Standard: Change Process

Summarized in the Task force on Student Life and Learning 1998

Project – Centric: a Shift in the Center of Gravity for Undergraduate Education

- Subject Centric: well-defined sequence of coursework of increasing specialization
  - Evaluated through closed-ended problem solving
  - Projects viewed as supplemental, diminishing time available for the “core”.
- Project Centric: the center of gravity shifts to the projects
  - Projects are supplemented by Subjects, digital education, faculty mentoring and self study, which stress the fundamentals
  - Students choose a thread of projects, while subjects etc. are selected from departments and taken modularly
  - Projects form a basis of evaluation
- Flexibility (in terms of maker/discoverer, choice of emphasis) achieved by:
  - Choosing projects that suit their interest, and designing an appropriate set of supporting coursework to gain the fundamental knowledge
  - The means of acquiring the fundamentals is less important than demonstration that the student has acquired and can apply the knowledge

Principles of Learning – Well Guided Projects

1: Susan Ambrose, How Learning Works: 7 Research Based Principles for Smart Teaching

2: Richard Mayer, The Case for Guided Methods of Instruction

- Students prior knowledge can help or hinder teaching (1)
  - Have to provide knowledge
  - Have to build upon it and activate it
  - Early project develop and activate "prior knowledge"
- How students organize knowledge influences how they learn and apply what they know (1)
  - Absent structure, knowledge decays quickly
  - Experts' structure is different from early learner
  - Projects provide knowledge and structure
- Student's motivation determines, directs and sustains what they do to learn (1)
  - Values and self efficacy create motivation
  - Leads to behavior and eventually performance
  - Projects excite and motivate students
- But ample evidence that instruction should be guided (2)
  - Cognitive activity vs. behavioral activity
  - Instructional guidance vs. pure discovery
  - Curricular focus vs. unstructured exploration

Functional Requirements for NEET Projects – the Integrating Element

- New machines and systems
- Reinforce fundamentals
- Build self efficacy

- Interdepartmental
- Intermediate guidance, scaffolded
- Making – but discovering option
- Progression of skills, authenticity, challenge – a system of projects

The NEET Charter

from the Dean of Engineering

The program will…

- be built on the established principles of MIT
  - Useful knowledge, Learning by Doing, Fundamentals
- focus on new machines and systems

via…

- a balanced approach to analysis and synthesis
- a foundation in modern engineering pedagogical approaches

BOLD change on potentially large scale at MIT

"… that will best serve the nation and the world in the 21st century." (from MIT Mission)

Strategic Development

- Create a four year pilot program
- Upper class years
  - Use existing flex degrees
  - Launch threads A and B in Fall of 17, and continue roll out over next three academic years
  - Launch threads C and D in Fall of 18, followed by E… Fall of 19
- Freshman year
  - Organize NEET themed Freshman Advisor Seminars for Fall 17
  - Pilot NEET freshman learning communities in Spring 18, and launch in Fall 18
  - Create freshman companion projects by Fall 18
- Draw in other schools to support project and ways of thinking

Standard: ?

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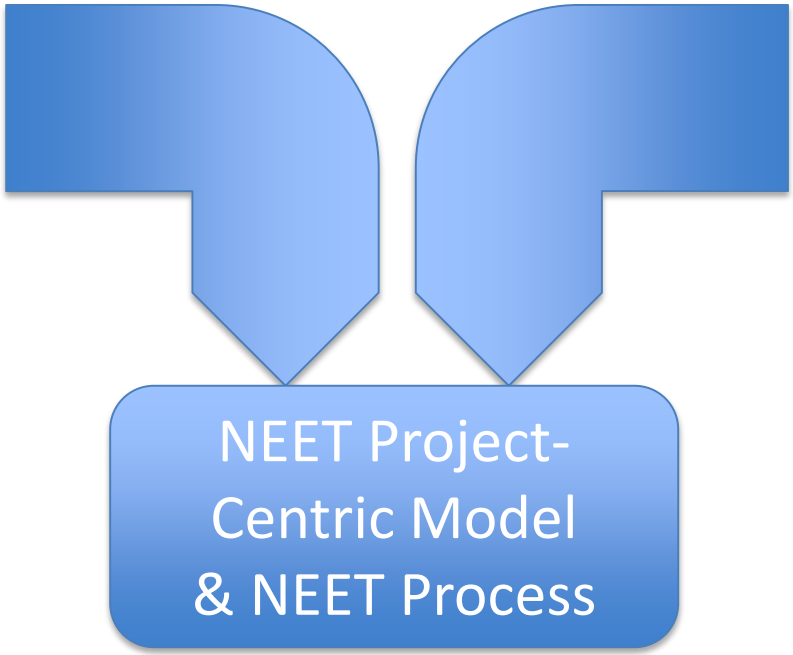
Standard: 4 Intro to Engineering

Evolution of Ideas

Evidence

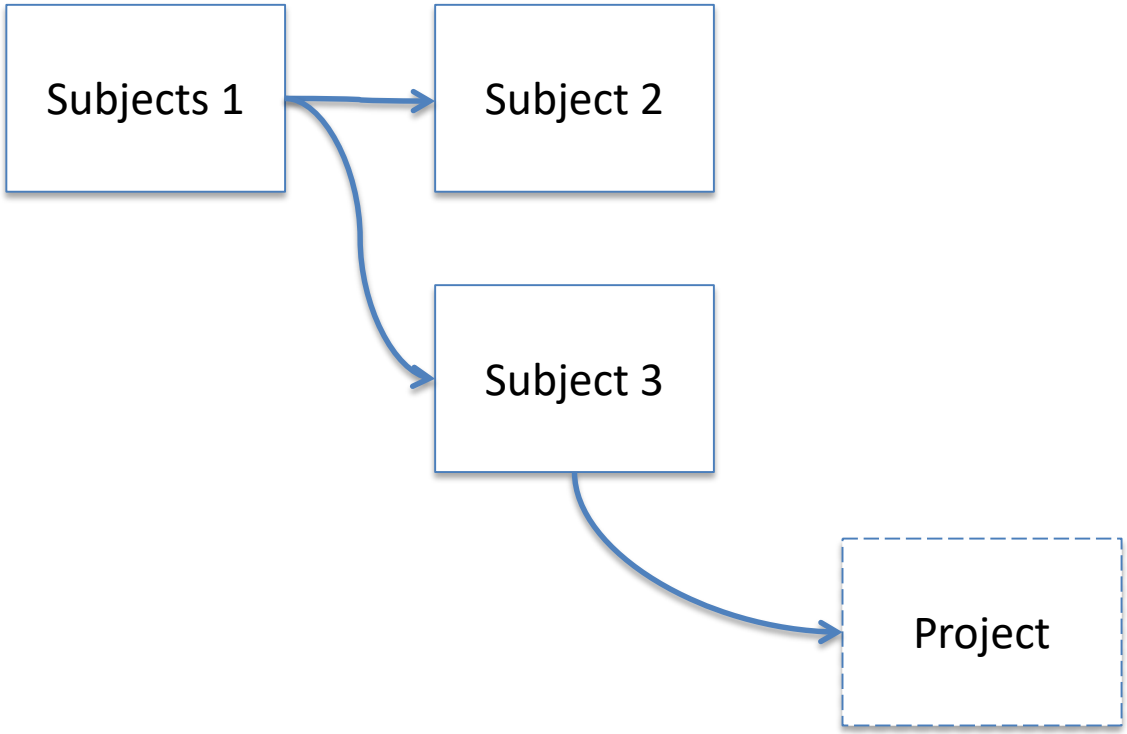
- Thought leaders
- Benchmarking
- Industry
- Alumni
- Students
- Faculty



Principles

- New Machines
- Makers and discoverers
- Pedagogy to support how students learn
- Ways of thinking
- Bold

The Current Subject Centric Major Scheme

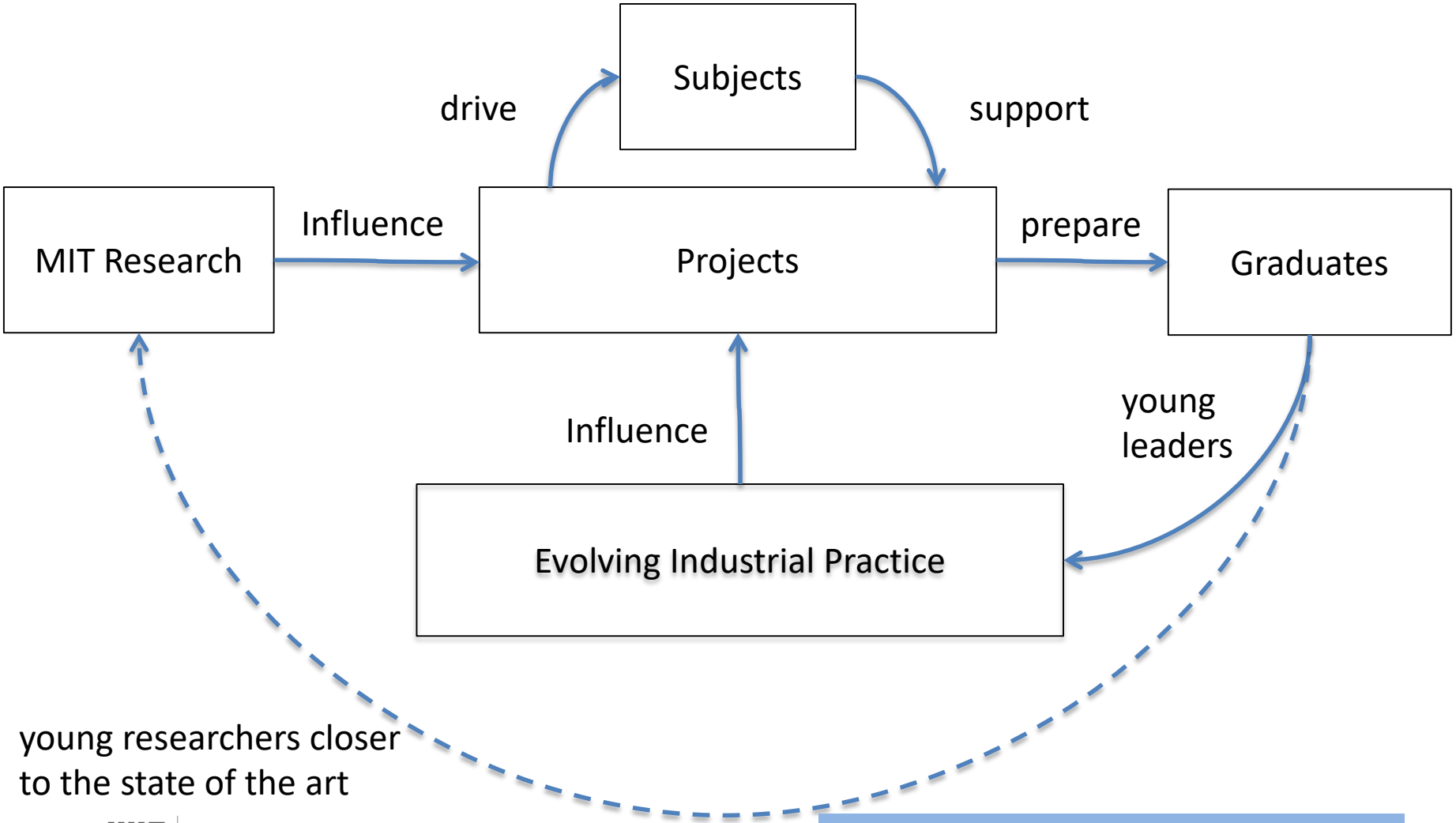


All modules also yield learning retained for life

Attributes of New Machines & Systems

- Integrate: mechanical, informational, molecular, biological, and energetic components
- Complex
- Highly networked and part of larger systems of systems
- Higher levels of autonomy and independence of action
- Support a sustainable environment

NEET Process of Renewal



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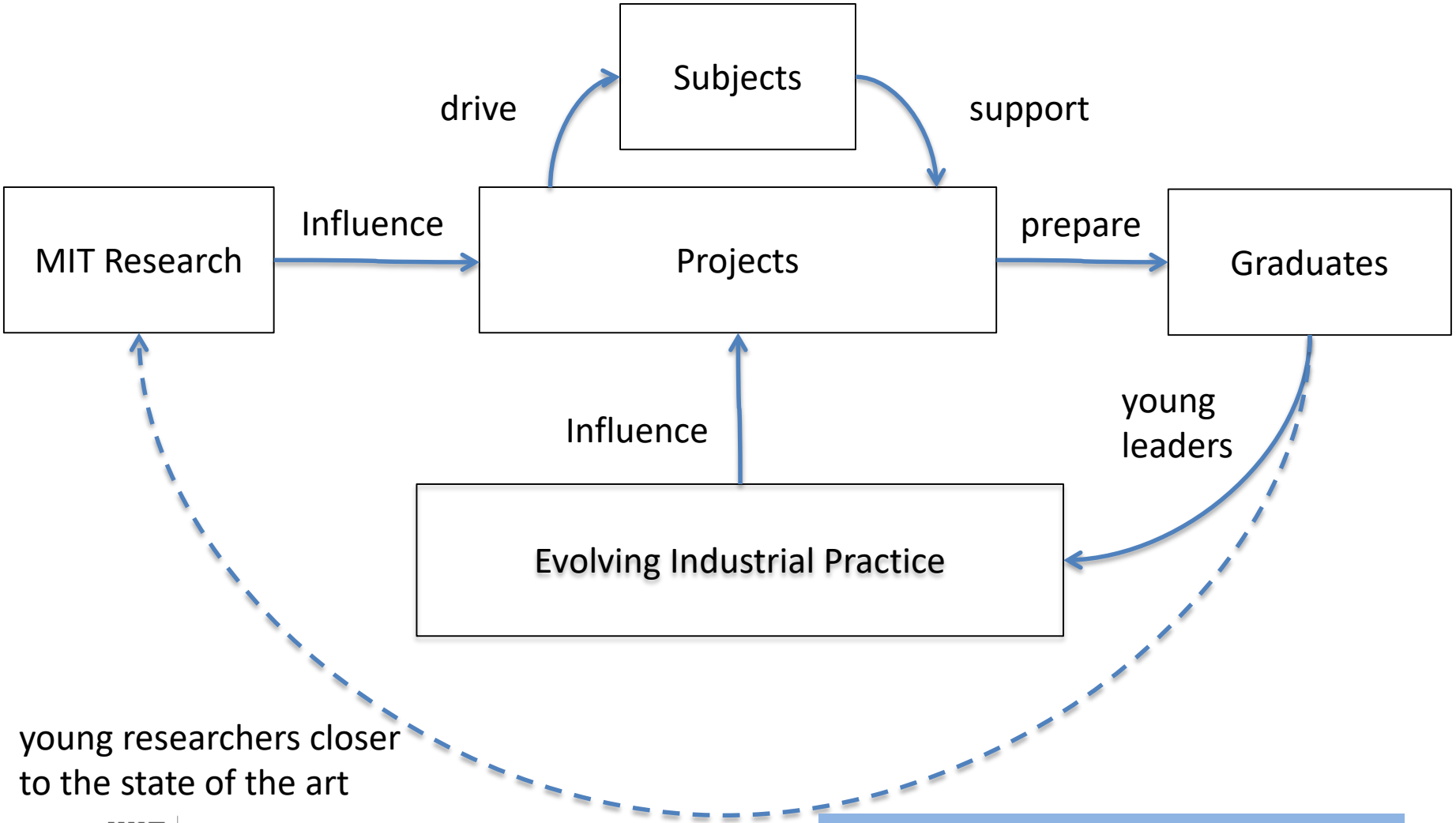

Standard: 12 Program Evaluation