

New Engineering Educational Transformation (NEET) An Instance of a CDIO Program

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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



Skoltech Mission – Accelerating Innovation

Skolkovo Institute of Science and Technology

- To have fundamental educational, scholarly and economic impact in the Russian Federation and around the world,
- By accelerating innovation: building integrated research/innovation programs to effectively meet the needs of industry and society, and educating graduate students to be leaders in translating knowledge from science to innovation



RESEARCH
EDUCATION
INNOVATION

Skoltech is a new model of educational institution

Skoltech Stakeholder Based Learning Outcomes

- 1. Disciplinary Knowledge and Reasoning
 - Mathematics and science
 - Applied science and engineering
 - Innovation and entrepreneurship
 - Interdisciplinary thinking
 - Contemporary methods and tools
- 2. Thinking Beliefs and Values
 - Cognition and modes of reasoning
 - Attitudes and learning
 - Ethics, equity and other responsibilities
- 3. Relating to others: communications and collaboration
 - Communications and working in international settings
 - Teamwork
 - Collaboration and change
- 4. Leading the Innovation Process
 - Making sense of the global, societal, environmental and business context
 - Visioning – inventing new technologies
 - Visioning – conceiving and designing
 - Delivering on the vision – implementing and operating
 - Delivering on the vision – entrepreneurship and enterprise

Engineering +
Leadership +
Innovation

**Standard 2: Learning
Outcomes**

The CDIO Standards: An Effective Practice Framework

1. The Context: adopt lifecycle context
2. Learning Outcomes: knowledge and skills
3. Integrated Curriculum: 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



The NEET Charter

from the Dean of Engineering



The program will...

- be built on the established principles of MIT
- 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)

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: ?

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Standard: Change Process

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,
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Standard: 1 Context

Old Machines → New Machines

The Airplane



1950's "Old Machines"

Today's "New Machines"

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

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.



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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: ???

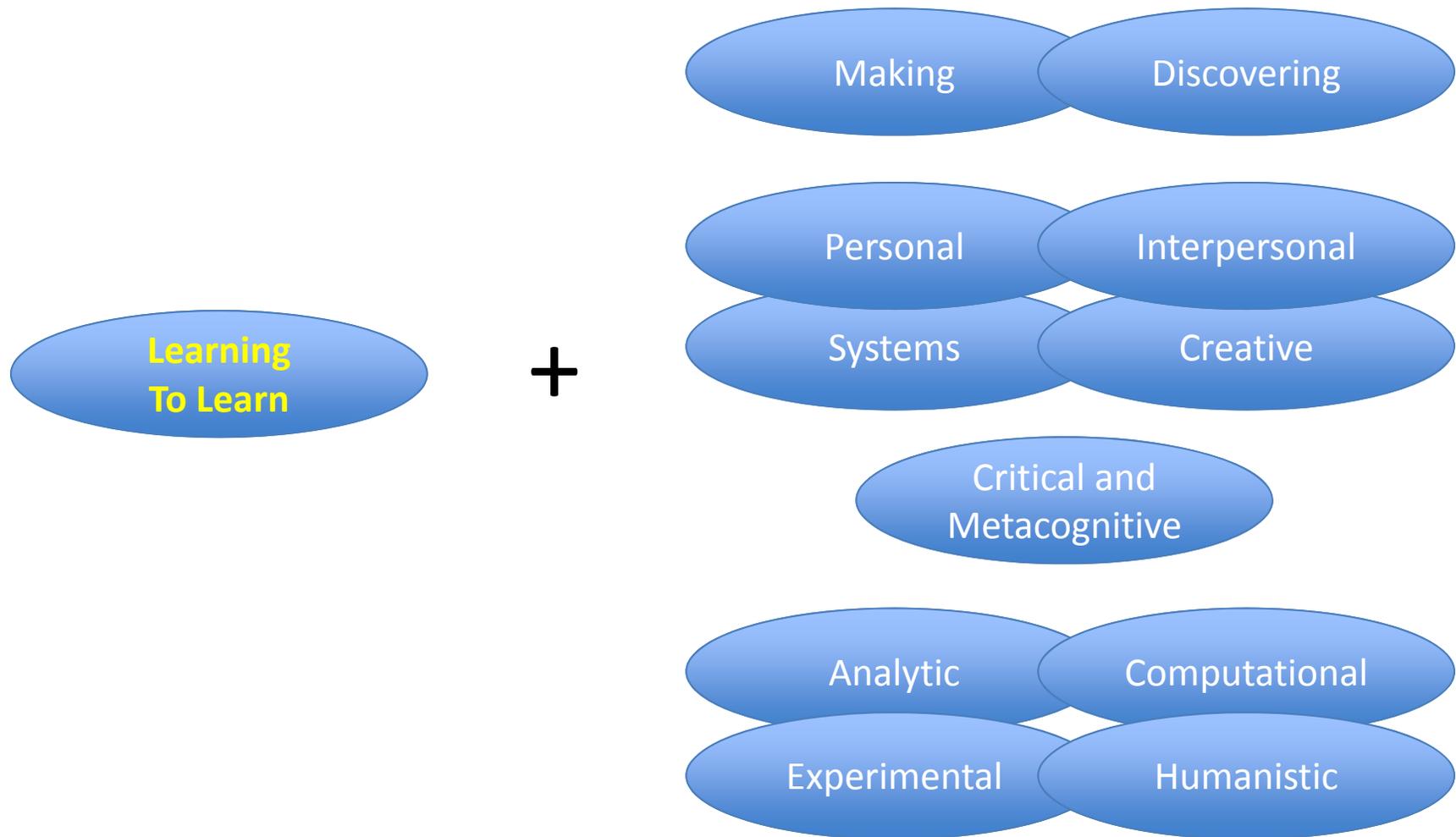
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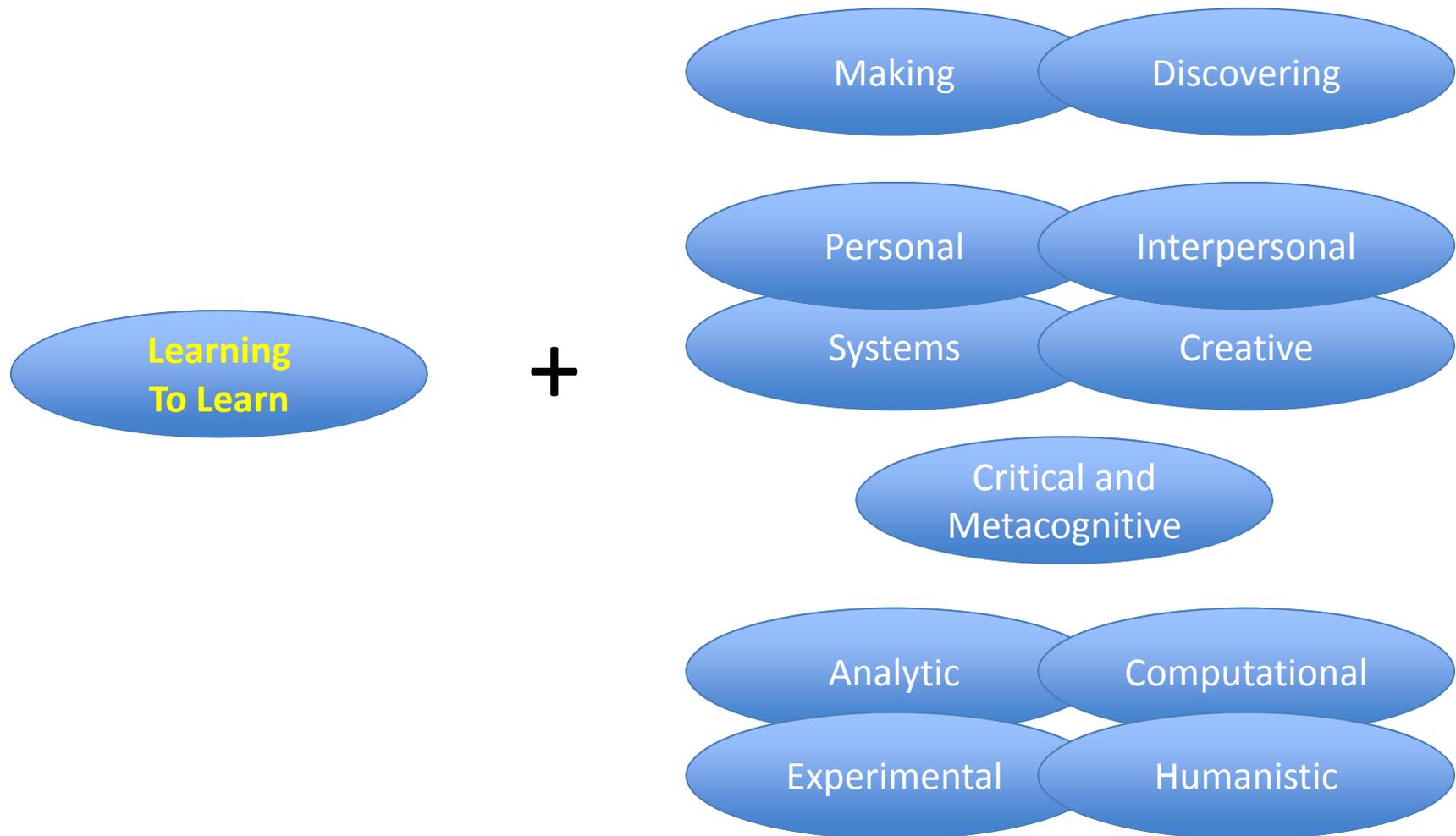
Principle #4 – Ways of Thinking

- 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



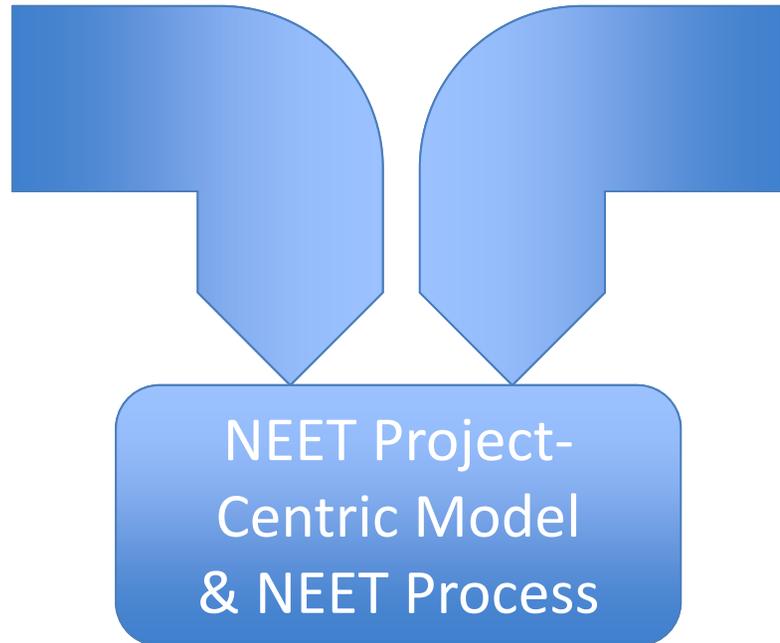
NEET as an Education in Ways of Thinking



Evolution of Ideas

Evidence

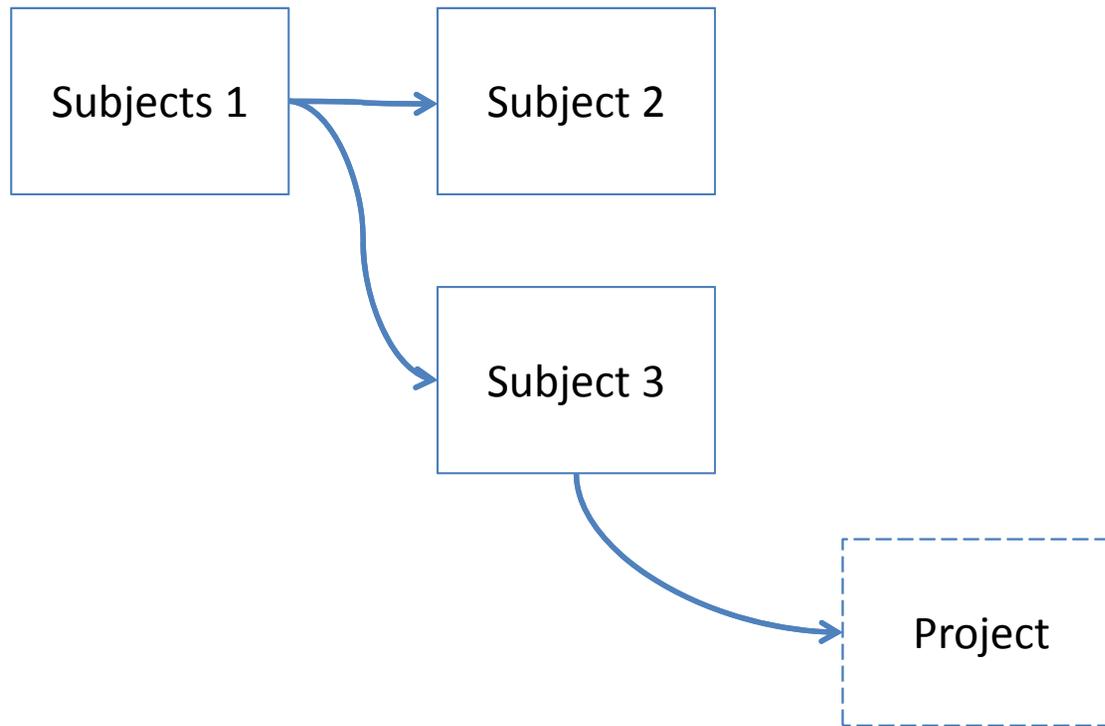
- Thought leaders
- Benchmarking
- Industry
- Alumni
- Students
- Faculty



Principles

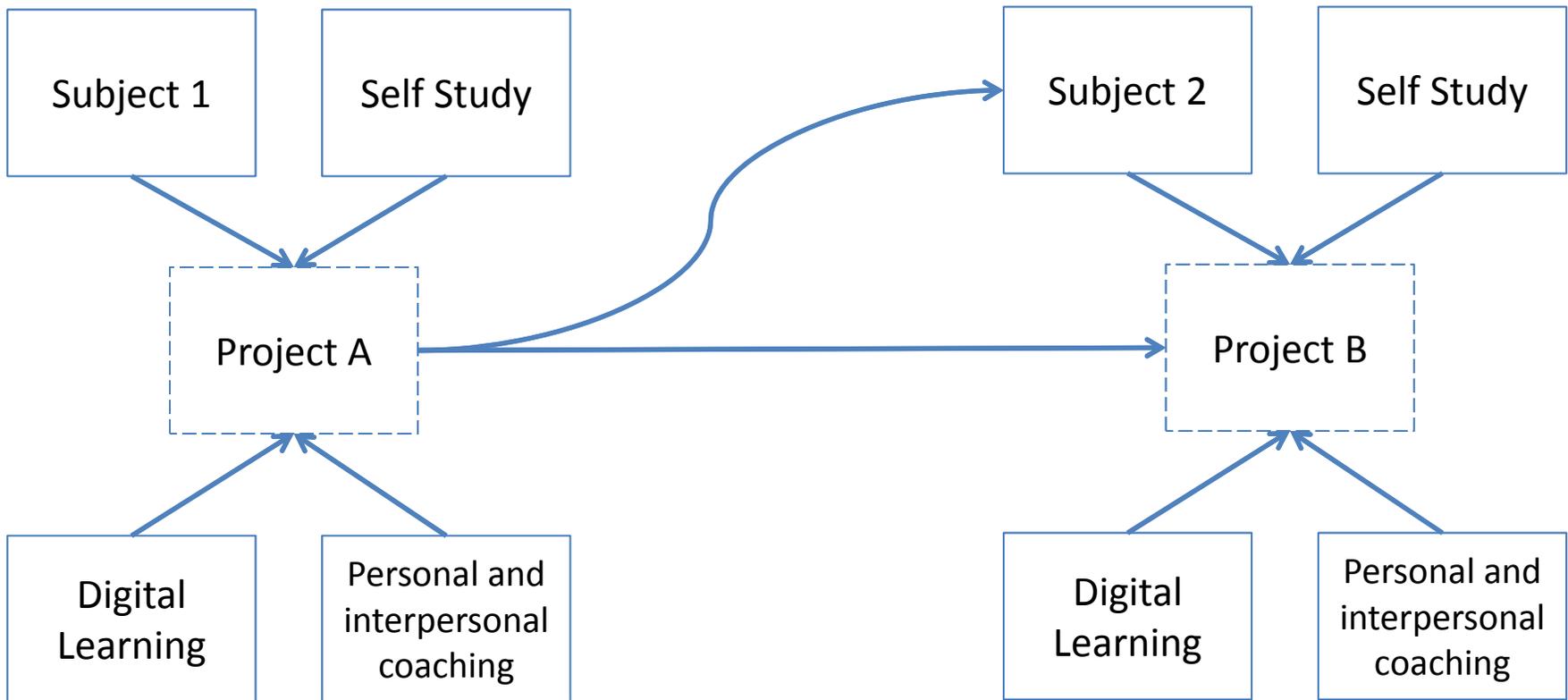
- New Machines
- Makers and discoverers
- Pedagogy to support how students learn
- Ways of thinking
- Bold

The Current Subject Centric Major Scheme



All modules also yield learning retained for life

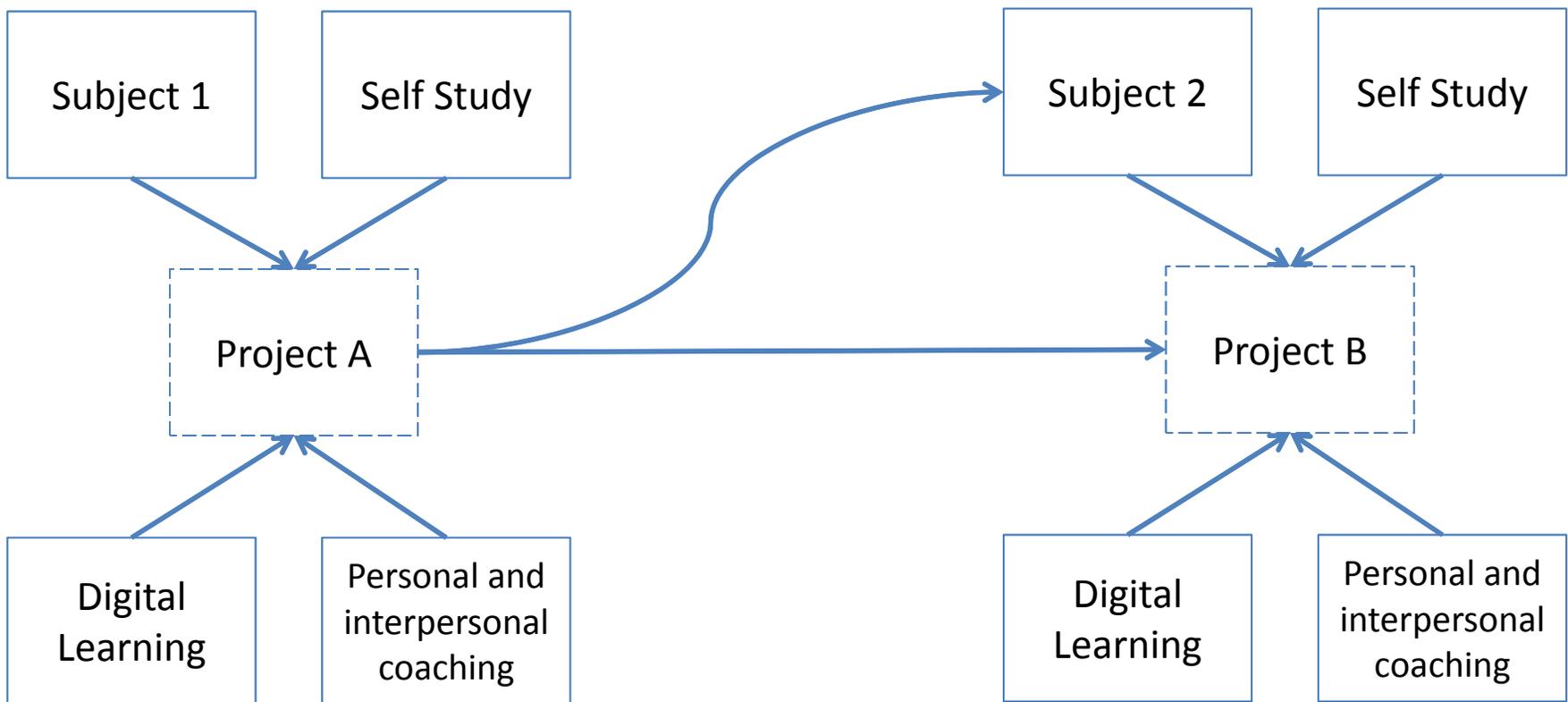
NEET Project Centric Curricular Construct



All modules also yield learning retained for life

Standard: ???

NEET Project Centric Curricular Construct



All modules also yield learning retained for life

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

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

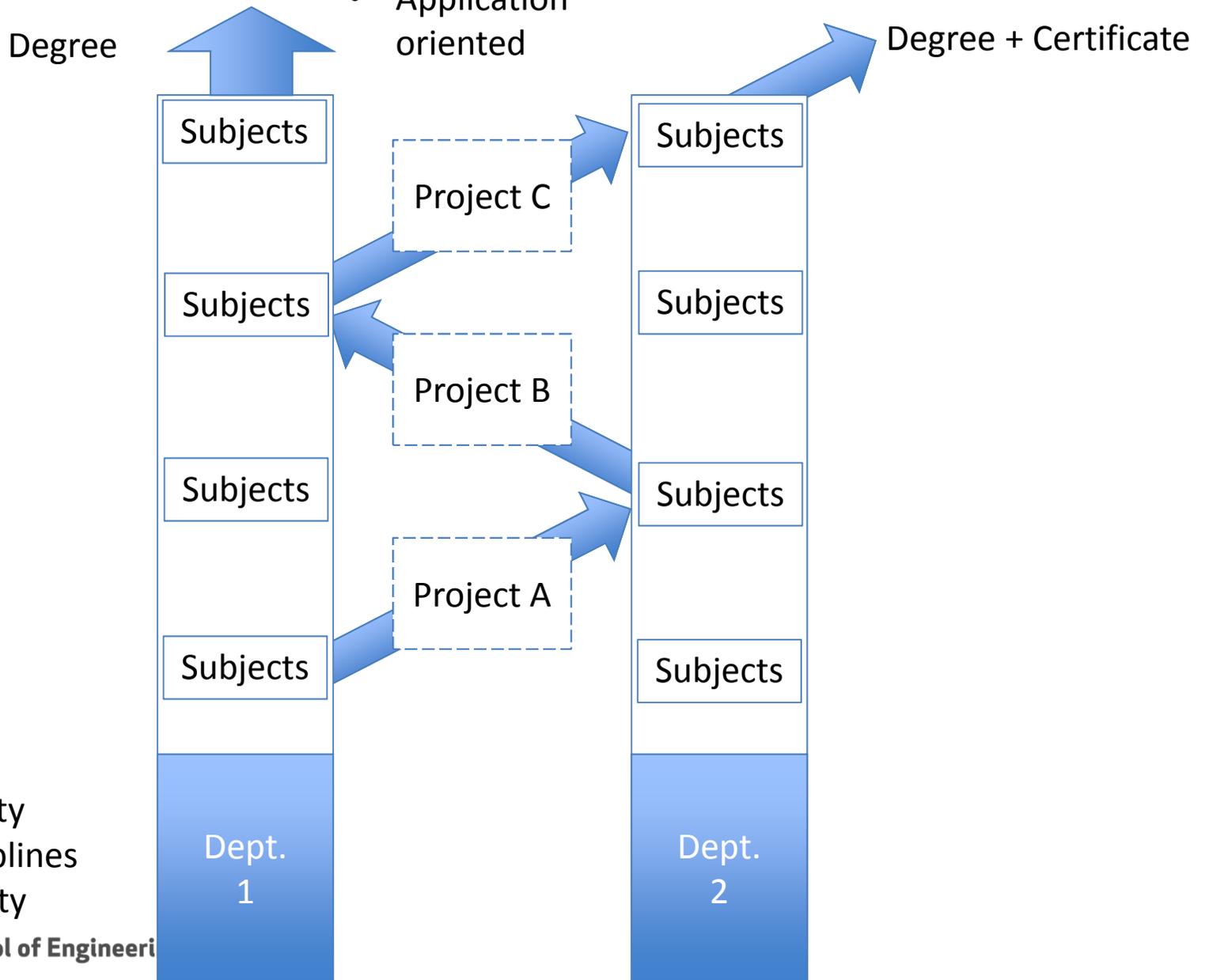
- Interdepartmental
- Intermediate guidance, scaffolded
- Making – but discovering option
- Progression of skills, authenticity, challenge – a system of projects

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)
 - Material Machines (materials manufacturing)
 - Sustainable machines (sustainable materials and energy)
 - Living Machines (biomedical diagnostics and therapeutics)
- Next group of programs
 - Internet of Machines (internet of things)
 - Data Machines (Data analytics)
 - Urban Machines (Smart cities)
 - Network Machines ((networks and systems)

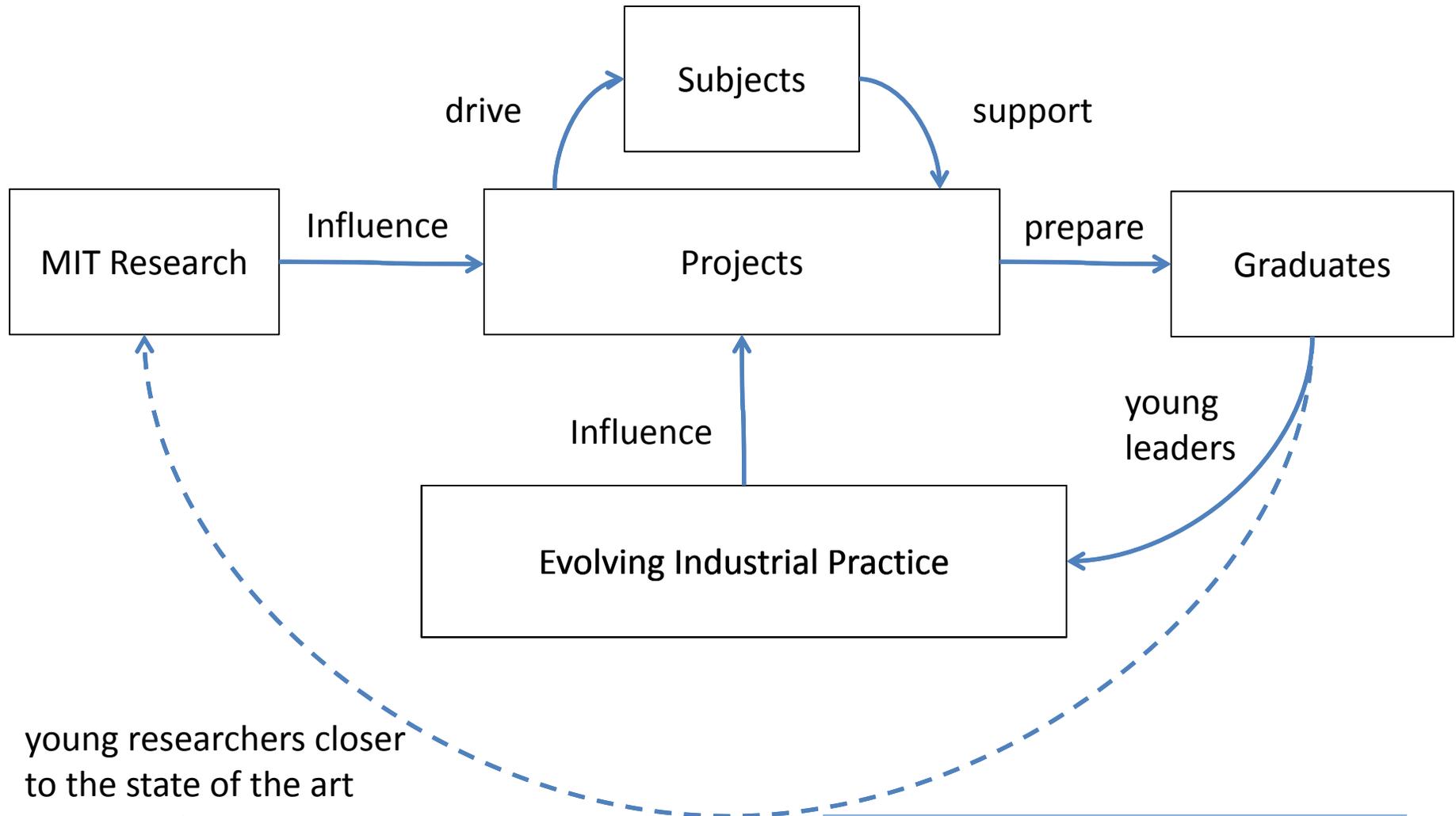
Strategic Development

- 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

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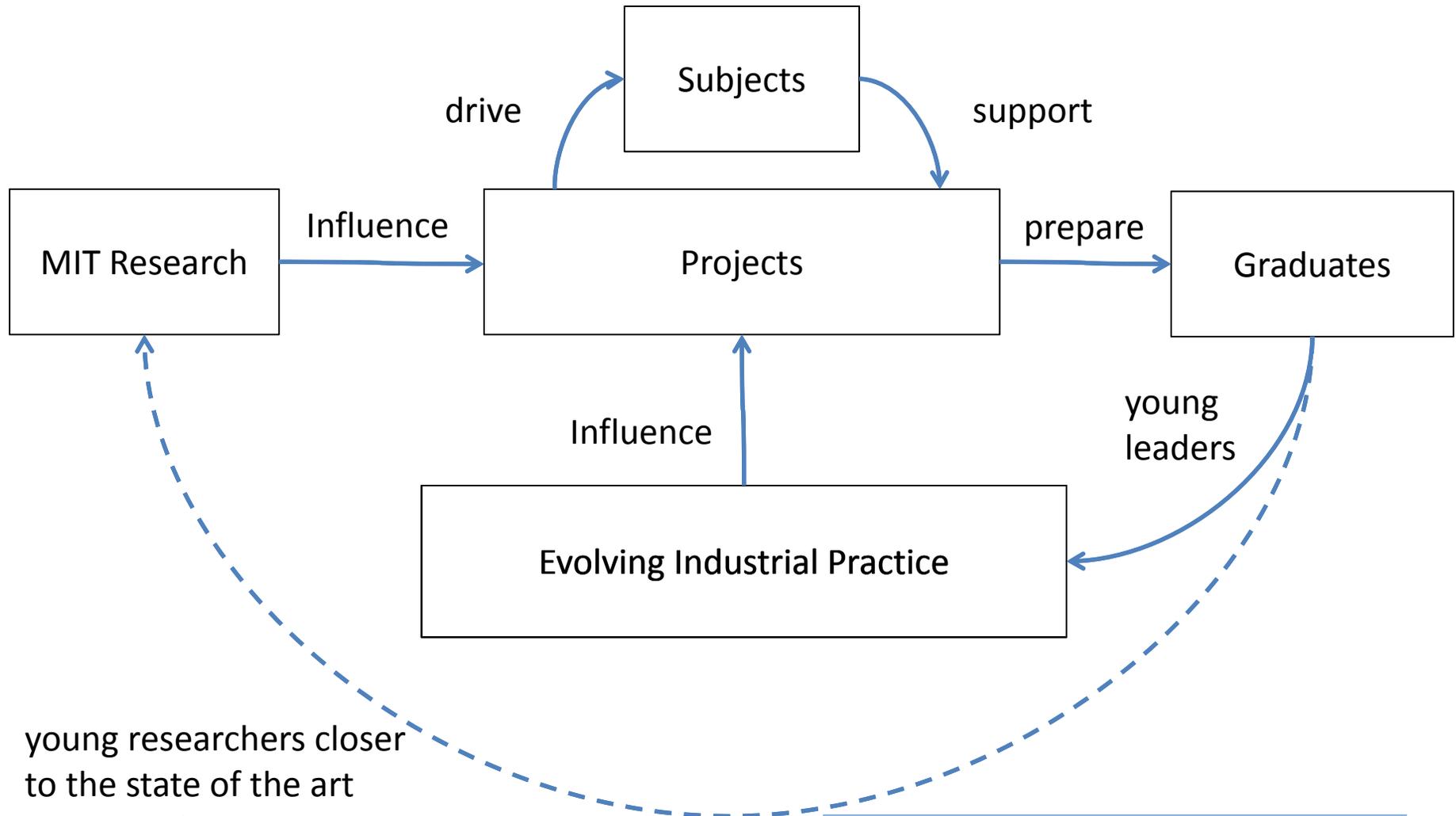
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NEET Process of Renewal



young researchers closer
to the state of the art

NEET Process of Renewal



Thank You

Which one did I leave out??