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Models and Instruments for CDIO Assessment

2007 -2009 First Year PjBL Effectiveness

- Defining and explaining Self-Efficacy
- Authentic experience as central cause of self-efficacy
- MIT freshman Project-Based Learning
- Evidence of the value of first year practice

Methods and the 2009-2010 Early PjBL Pilot Study

- Models of entrepreneurial desirability & intention
- CDIO syllabus as origin of task items
- Eleven point response structure
- Self-efficacy, Desirability and Intentional Behavior

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Background to Year MIT Experiment

- MIT Task Force on the Undergraduate Curriculum conducted year-long review of its General Institute Requirements, what is required for all undergraduates.
- Conclusion: Whatever other approaches are taken in the 4-year engineering curriculum, the essence of engineering - the iterative process of designing, building, and testing - should be taught in the first year.
- The same principle was believed to to apply to many sciences, urban planning, architecture and other fields of study.

- Faculty votes to support three year experiment to study effects of project learning.

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Project-Based Subjects

- Funding for teaching assistants and materials were provided for five new freshman courses:
  - Urban studies
  - Energy
  - Mechanical engineering
  - Bio-engineering
  - And two in electrical engineering and computer science.
- Existing PjBL engineering subjects for freshman already offered by Aero/Astro and Earth Sciences were continued.
- And a strong assessment plan was developed.

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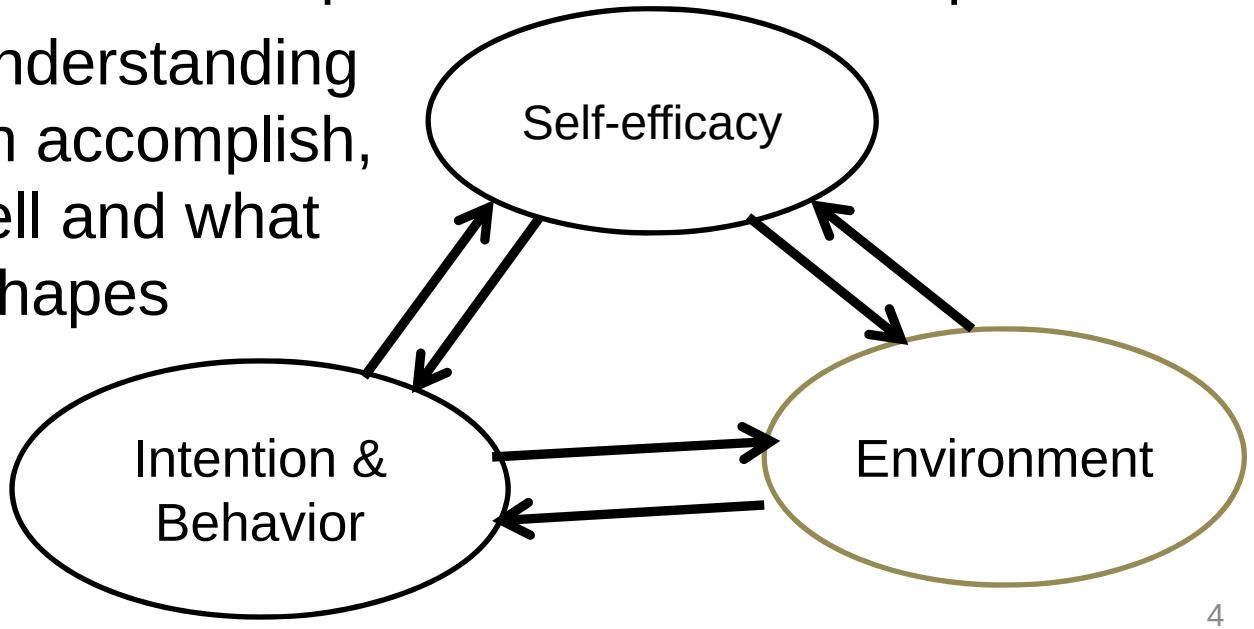
Assessment Team Decided to Focus on Self-Efficacy & Behavior

"Perceived self-efficacy refers to belief's in one's capabilities to organize and execute the courses of action required to produce given attainments." Bandura (1997, p.3)

<u>Central to self-regulation and human agency</u>

- We observe our behaviors, so the tasks we attempt and how well we perform them shapes our view of our capacities.
- An informed understanding of what we can accomplish, what we do well and what we do badly, shapes our interests and behavior.



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Self-efficacy Develops in a Process of Differentiation

Self-efficacy is **not** general Self-confidence or Self-esteem

- Personality traits are often measured by non-specific items (e.g.,“Most of the things I try I do successfully”).
- They are generally poor predictors of behavior.
- Self-efficacy is domain specific, and the items used to measure it are about actions specific to each context.

Differentiation begins at an early age

- By 7th grade, we have already developed highly diverse and separate judgments about our abilities for math, English, athletics, art and many other areas.
- Areas of higher self-efficacy become areas of leading interests, are pursued, and shape career intention.

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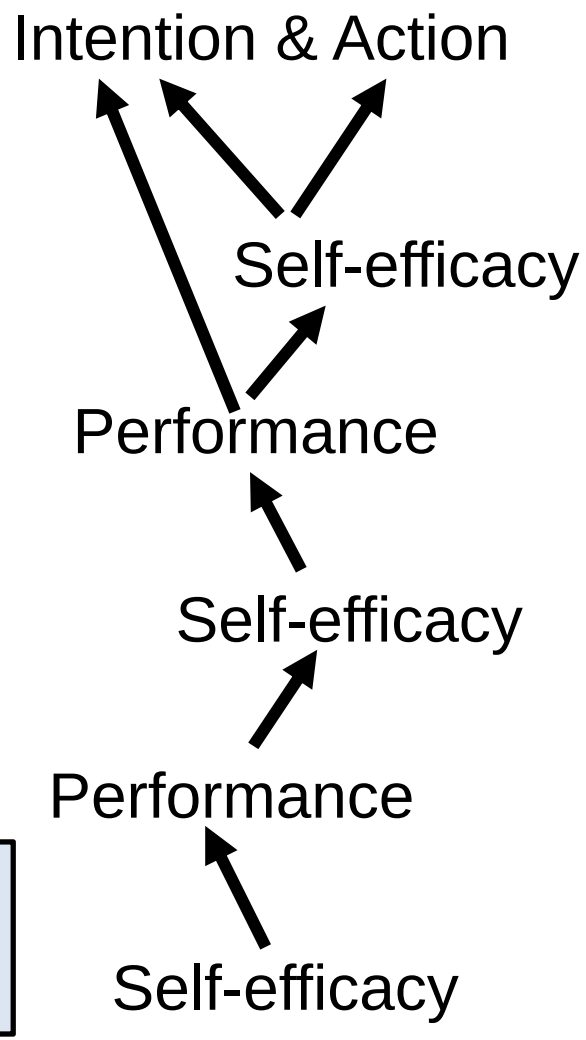
Self-Efficacy as a Platform

- With successful performance of tasks, self-efficacy increases and performance at one level encourages the individual to take on tasks of greater difficulty, which increases self-efficacy further.
- Low self-efficacy discourages performance, and leads to the avoidance of challenging tasks.
- One pursues what one does well. If you do many things well, you pursue what you do best



Note: a specific self-efficacy is often a rough indicator of actual capability.

Measuring Math Self-efficacy Impact on STEM Careers

Self-efficacy is often as important as actual ability

- Mathematics self-efficacy is known to be persistent predictor of science, engineering and math careers.
- A national study of 24,599 high school students in1984 found 2500 students intending to pursue STEM careers.
  - As part of the study they were asked about their confidence that they could perform a long series of mathematical operations without actually doing so.
    - Providing a measure of math self-efficacy.
  - Data on their performance on standardized math tests were added to their survey data.
    - Providing a baseline of both mathematics self-efficacy and actual ability on standardized tests.

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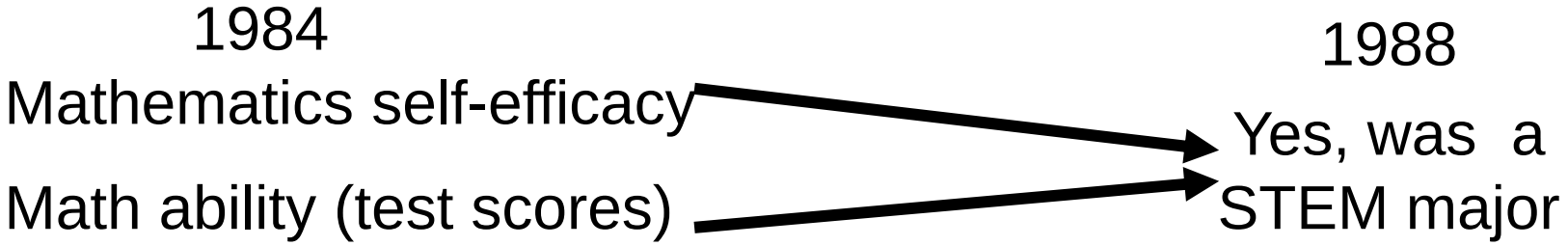
Measuring Math Self-efficacy Impact on STEM Careers

Self-efficacy is often as important as actual ability

- The students were located again in1988 and asked if they were enrolled in STEM majors, and information gathered on decision points in their academic careers since 1984.
- The data were then modeled to determine their relative predictive power.



- The predictive power of self-efficacy and test scores was roughly equal, largely because of self-limiting career decisions. Self-efficacy was as important as actual ability.
- Weak math self-efficacy was a major factor explaining why young women do not pursue STEM careers.

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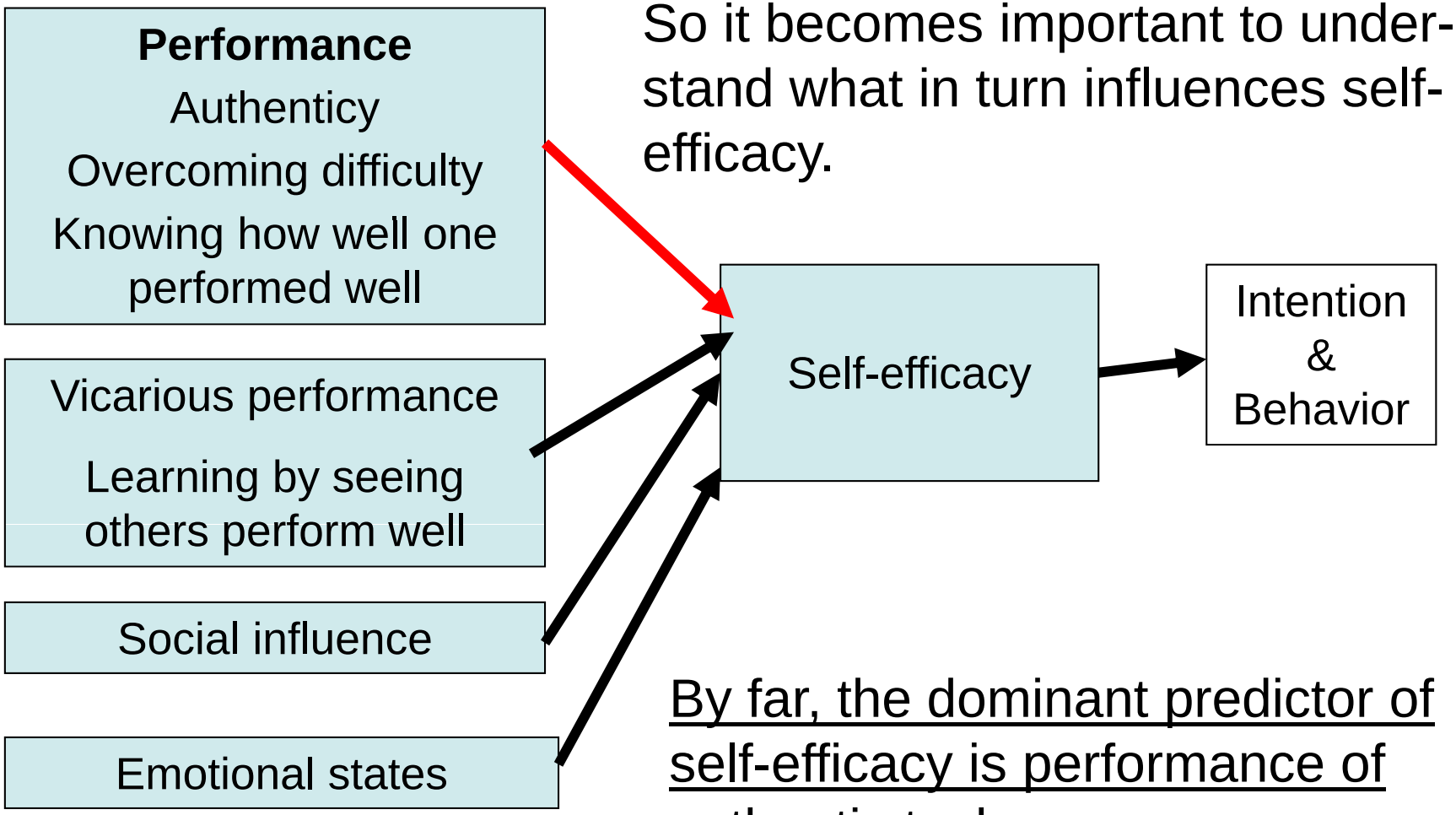
Bandura's Predictors of Self-efficacy



So it becomes important to under-stand what in turn influences self-efficacy.

By far, the dominant predictor of self-efficacy is performance of authentic tasks.

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The Effect of UK Industry Experience Exploring the Role of Authenticity

Type of work experience	Perceived self-efficacy for technology (N)	
No work experience in prior year	53.1%	(88)
University, other educational organization	52.9%	(23)
Government organizations and nonprofits	53.8%	(47)
Industry or business organizations	55.4%	(249)
Total	54.1%	(407)

- Result first found in pilot survey of 150 engineering students.
- Confirmed six months later in study of 1,900 undergraduates at the four British universities.
- Because of the pilot, we were prepared for the outcome, and had included questions about the nature of their work

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Relative Importance of Elements of Background and Work Experience

Using regression analysis on technology self-efficacy to establish relative importance of work experience factors

Activity	beta	t values
Men	.226	3.808***
Father runs his own business	.088	1.492 n.s.
Rotated through departments	.106	1.763✧
Authentic, close to studies	**.225**	3.155**
Difficulty of work performed	.127	1.810✧
How well work was performed	.121	2.004*

R^2 change = 12.1%; df = 4, 235; F change = 8.841; p < .001
df = 6, 235; F = 9.358, p < 001;

***p<.001,**p<.01, *p<.05, ✧p<.1, n.s. = Not significant

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The Effect of UK Industry Experience Measuring Technology Self-efficacy

- Format can vary. Bandura uses wide, 11 point range that provides for long term improvement over university career**.**
- Items co-mingled with other topics to minimize response set.

“How confident are you that can….”

Not at all confident					**50%**					**Completely confident**
0%										**100%**
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Convert a scientific advance into a practical application.

Develop your own original hypothesis with plan to test it.

Grasp limits of a technology to see the best ways to use it.

Design & build something new that performs to specification.

Lead a technical development team to a successful result.

Teaming Self-efficacy Items

How confident are you that you can:

	Not at all confident									**Completely confident**
	0%				**50%**					**100%**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

- Give constructive criticism to a team member who is not performing well.
- Motivate others to work long hours to meet a deadline.
- Facilitate a group with members who strongly disagree so the group can reach a successful project solution.

Alpha coefficient of scale reliability = .92

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Project-Based Learning at MIT
Evaluation Design

Pre-collegiate build/ create experiences **August 2007 (T_0)**

Technology self-efficacy **August 2007 (T_0)**

Team skills self-efficacy **August 2007 (T_0)**

Freshman PCL course with engineering focus

Technology self-efficacy **May 2008 (T_1)**

Team skills self-efficacy **May 2008 (T_1)**

Design set up with controls for having prior project experience and pre-existing levels of self-efficacy.

Selecting engineering major **Fall 2008 (T_2)**

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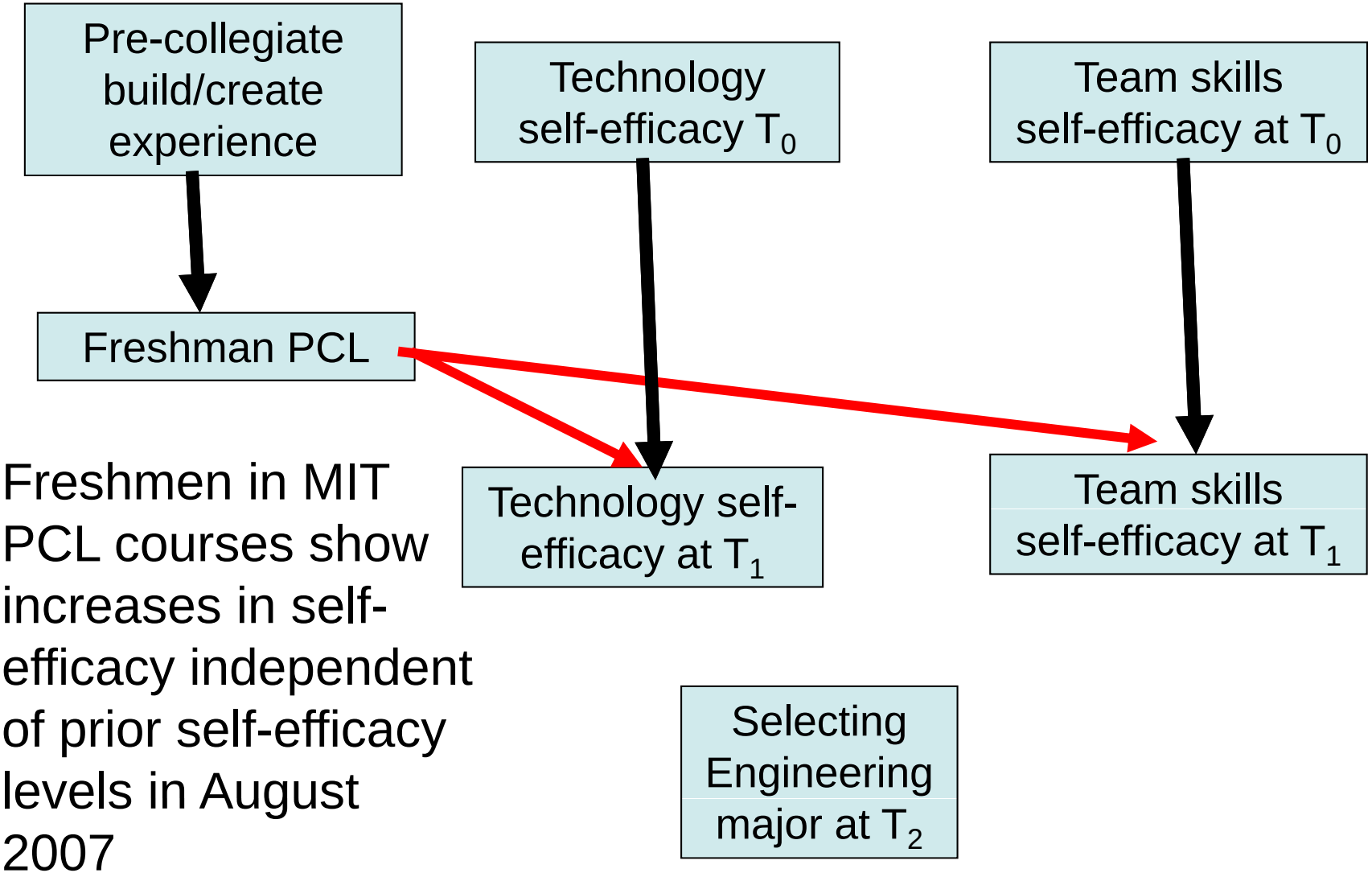
Evaluating Project-Based Learning at MIT



Freshmen in MIT PCL courses show increases in self-efficacy independent of prior self-efficacy levels in August 2007

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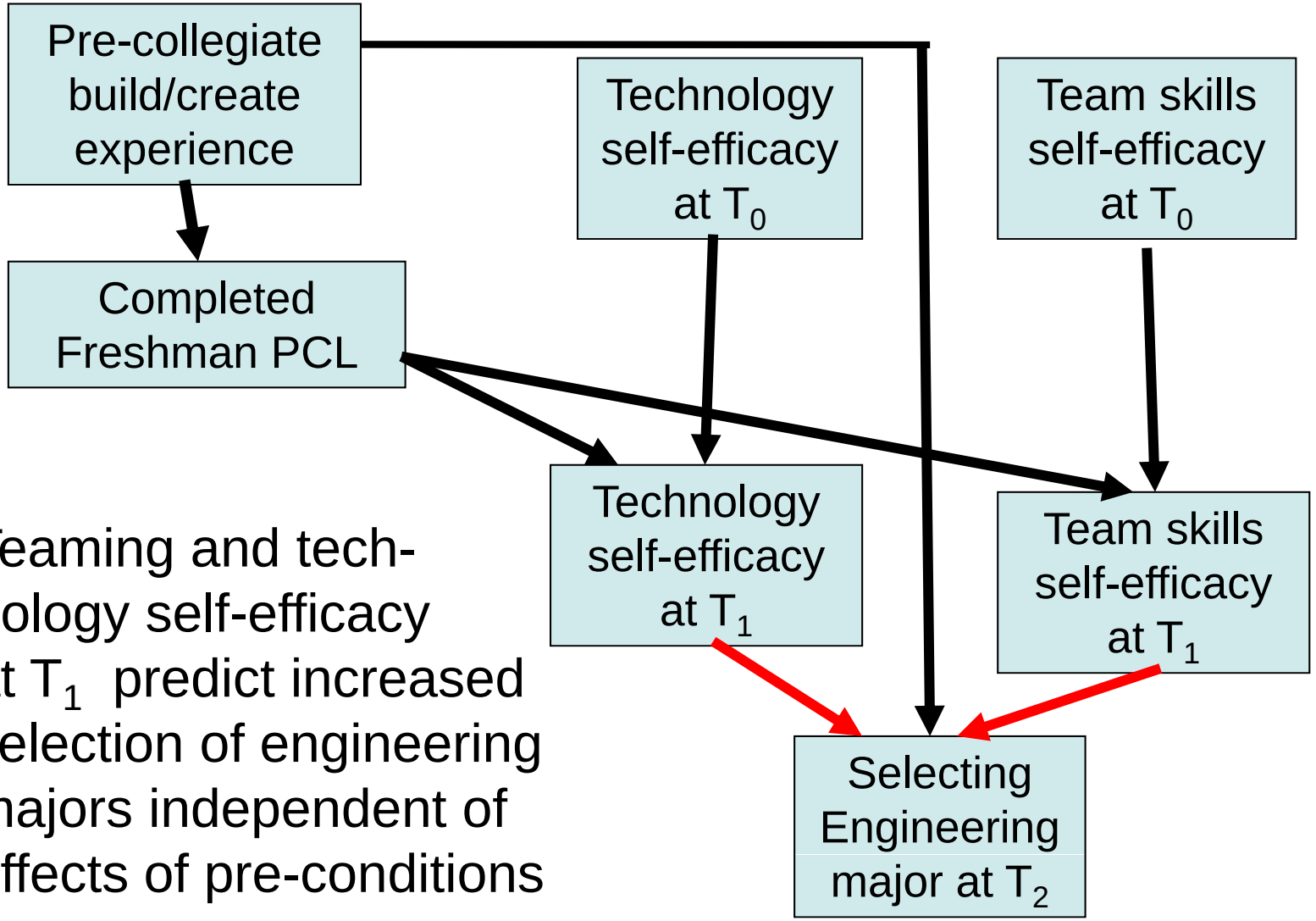
Evaluating Project-Centered Learning at MIT



Teaming and tech-nology self-efficacy at T_1 predict increased selection of engineering majors independent of effects of pre-conditions

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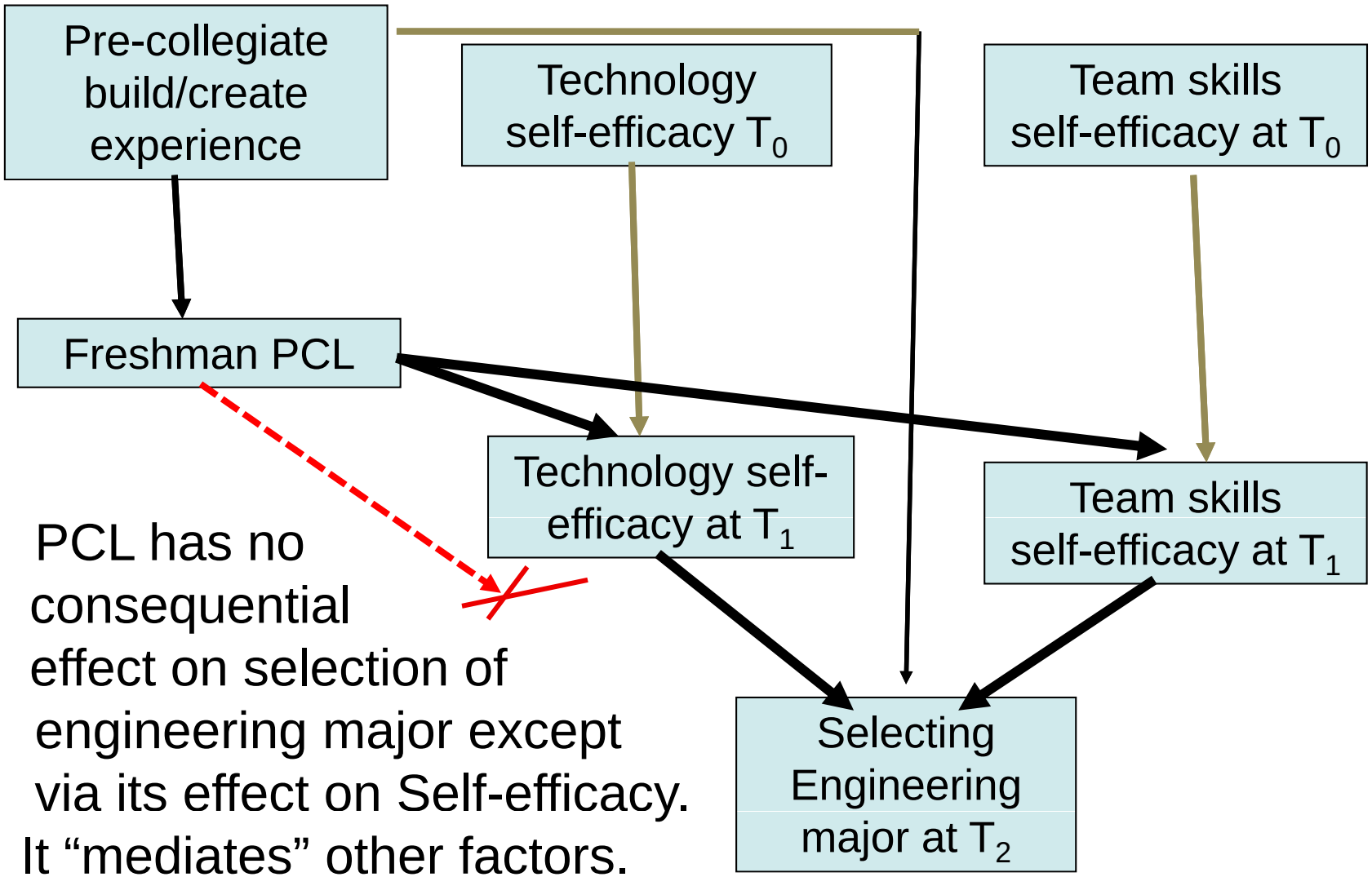
The Mediating Role of Task Performance in the Self-efficacy → Intention Relationship



PCL has no consequential effect on selection of engineering major except via its effect on Self-efficacy. It "mediates" other factors.

Current Status

- In Fall 2009, over 50% of the MIT faculty voted to require some form of practice for all MIT undergraduates.
- But it takes 60% to establish a requirement.
- There is widespread support for Project-Based Learning in the School of Engineering, and freshman are offered elective courses by most engineering departments.
- The percent of MIT students taking engineering as a percent of all undergraduates is increasing.
- We are working hard to find additional financial support for or new ways of working to deal with the added costs of project-based learning.

  E.g., using undergraduate assistants instead of graduate student Teaching Assistants