

Transforming Engineering Technology Education for the Digital Age

**The Purdue Polytechnic Institute
Purdue University**

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PURDUE
POLYTECHNIC



Higher Education Needs to Change

Challenges of 21st century teaching and learning

- Many students graduate from even our most elite universities with little or no conceptual understanding of science, math, and technology that they have spent 4 years studying
- They have learned the facts but not the ideas behind them
- The traditional model of higher education cannot account for the exponential growth of information
- For the 21st century, what you know is far less important than what you **can do** with what you know

Although students are different in what they know and how they learn, and although the skills most needed by industry and communicates have changed

Little has changed in higher education ... except everything else

Higher Education Needs to Change

Rethinking college

- A university is to create and transmit knowledge through research and teaching courses
 - After two years in college nearly half of all students showed no improvement in their complex reasoning, critical thinking, and writing skills*
 - Much of what is taught in college is now available free
 - The value of explicit information is rapidly dropping to zero

Academically Adrift, 2011



The World Has Changed

Rethinking Education

- The structure and curriculum in our schools and colleges has not kept pace with the evolution of the modern workplace.
- Our education system is too much like the world of work for the industrial age where punctuality, attention, and silence were valued above all else.
- Even college is very task based: take an exam, finish a paper, attend a club meeting, get the one right answer.
- Students are rewarded for having answers, not asking questions.
- The digital age require young adults to navigate the ambiguity of today's jobs with a mix of:
 - Hard fundamental discipline skills and knowledge
 - Refinement skills
 - Communicating and listening
 - Problem solving
 - Working in teams
 - Writing and reading

Game Changers

Harmonization and integration of many disciplines and discoveries

- The Fourth Industrial Revolution, Second Machine Age, Digital Convergence, Industry 4.0
- Characterized by the convergence/integration of:
 - Artificial Intelligence (AI)
 - Robotics
 - Internet of Things (IoT)
 - Quantum Computing
 - Data Science and Analytics
 - Nano-technology
 - Materials Science
- A Fusion of Technology Across the Physical Digital and Biological Worlds

Key findings of surveys of employers*

* Hart research associates

- Knowledge of Human Cultures and the Physical/Natural World
 - Broad knowledge in the liberal arts and sciences – 80%
 - Global issues and knowledge about societies and cultures outside the United States – 78%
 - Direct experiences with community problem solving – 86%
 - Applied knowledge in real-world settings – 78%
- Intellectual and Practical Skills
 - Critical thinking and analytic reasoning – 82%
 - Complex problem solving – 81%
 - Written and oral communication – 80%
 - Information literacy – 72%
 - Innovation and creativity – 71%
 - Teamwork skills in diverse groups – 67%
 - Quantitative reasoning – 55%



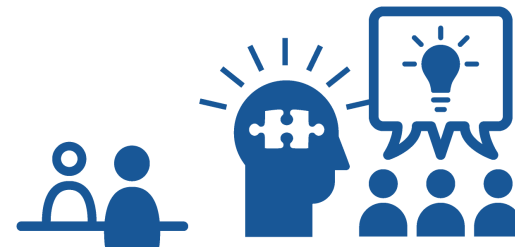
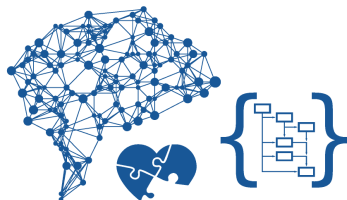
Top 10 skills

in 2020

1. Complex Problem Solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgment and Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

in 2015

1. Complex Problem Solving
2. Coordinating with Others
3. People Management
4. Critical Thinking
5. Negotiation
6. Quality Control
7. Service Orientation
8. Judgment and Decision Making
9. Active Listening
10. Creativity



Where Are All the Jobs?

- Detroit 1990
 - Three biggest companies had a combined market cap of \$36 billion, revenue of \$250 billion, and 1.2 million employees.
- Silicon Valley 2014 (none of these companies existed in 1990)
 - Three biggest companies had a combined market cap of \$1.09 trillion, revenue of \$247 billion but with about 10 times less employees at 137,000.
- Wealth is generated in the digital age today with much fewer workers compared with 10 or 15 years ago because digital businesses have marginal costs that trend towards zero.

Higher Education's Flaw

- Academic institutions have always been thought of as one of the foremost places to pursue forward-thinking ideas.
- Today career incentives and funding conditions support incremental, conservative changes over bold innovative ideas.
- We need to stop funding new initiatives in an attempt to change higher education.
- We need to invest in preparing change leaders and flip the faculty to change higher education
- Olin vs Purdue Polytechnic

The Digital Age

What we need

- STEM Graduates capable of addressing the grand challenge problems facing humanity and a workforce capable of contributing to the economic realities of the 21st century
- Deep preparation in traditional STEM subjects with a broad understanding of integrative systems thinking across academic boundaries
- Incremental changes have been tried for the last two decades funded by NSF and encouraged by ABET but systemic change has not been achieved

False Dichotomy

- The "life of the mind" versus "career preparation" dichotomy.
- Many administrators and faculty members believe that it's impossible to pursue both a liberal education and prepare for one's post-college career.
- It is the responsibility of higher-education institutions to move beyond this kind of counterproductive thinking to better support and prepare our graduates as they transition to their post-college lives.

Purdue Polytechnic Institute

Change From Within

- Purdue University initiative sponsored by President Daniels and the Board of Trustees
- Goal: To become a leading experimental college to transform STEM higher education from within and be a leader in K-12 STEM Education transformation
- Become a disruptive transformer and incubator for educational innovation
- Grand challenge question in undergraduate higher education: What if you could start over for the digital age?

Why polytechnic?

Updated definition

- The 21st century version of the Polytechnic:
 - New discipline for the thinking and creative economy
 - The T-shaped professional
- Our new definition of “polytechnic”:
 - A college that uses innovative learning methods, real-world experiences, and industry partnerships to produce graduates uniquely qualified for STEM professions



Ten elements of transformation

Requires significant advancements within each element, not minor evolutionary changes

Theory-Based Applied Learning	Learning-by-doing is core to the Polytechnic experience & requires an increased use of lab courses and/or in-class applied-learning activities
Team Project-Based Learning	Responding to industry, more team project-based learning is needed, and this should also include instruction on team dynamics/techniques
Modernized Teaching Methods	Improve student learning by replacing less effective traditional lectures with “Active Learning” methods – see “Cone of Learning” on CIE web
Learning in Context	Provide a richer learning experience via a purposed-based, just-in-time manner – requires inter-disciplinary synchronization – very challenging
Integrated Humanities Studies	Adjust courses/curricula to reap benefits of studying humanities within STEM framework; integration with TECH 120 is a model for years 2, 3, 4
Competency Credentialing	Create competency-based majors or degree programs by leveraging work done for college’s recently-approved transdisciplinary degree
Senior Capstone Projects	All plans of study should include a required two-semester senior capstone experience that is driven by industry or community partners
Internships	All degree programs should include a required internship or other workforce-like activity that is facilitated by the college and department
Global/Cultural Immersions	All plans of study should include a required activity that gives students an enriched perspective of the cultural-driven global marketplace
Faculty-to-Student Mentorship	A hallmark of the Polytechnic experience is the opportunity for every student to have a faculty mentor for professional guidance & support

High-Impact Educational Practices

What works

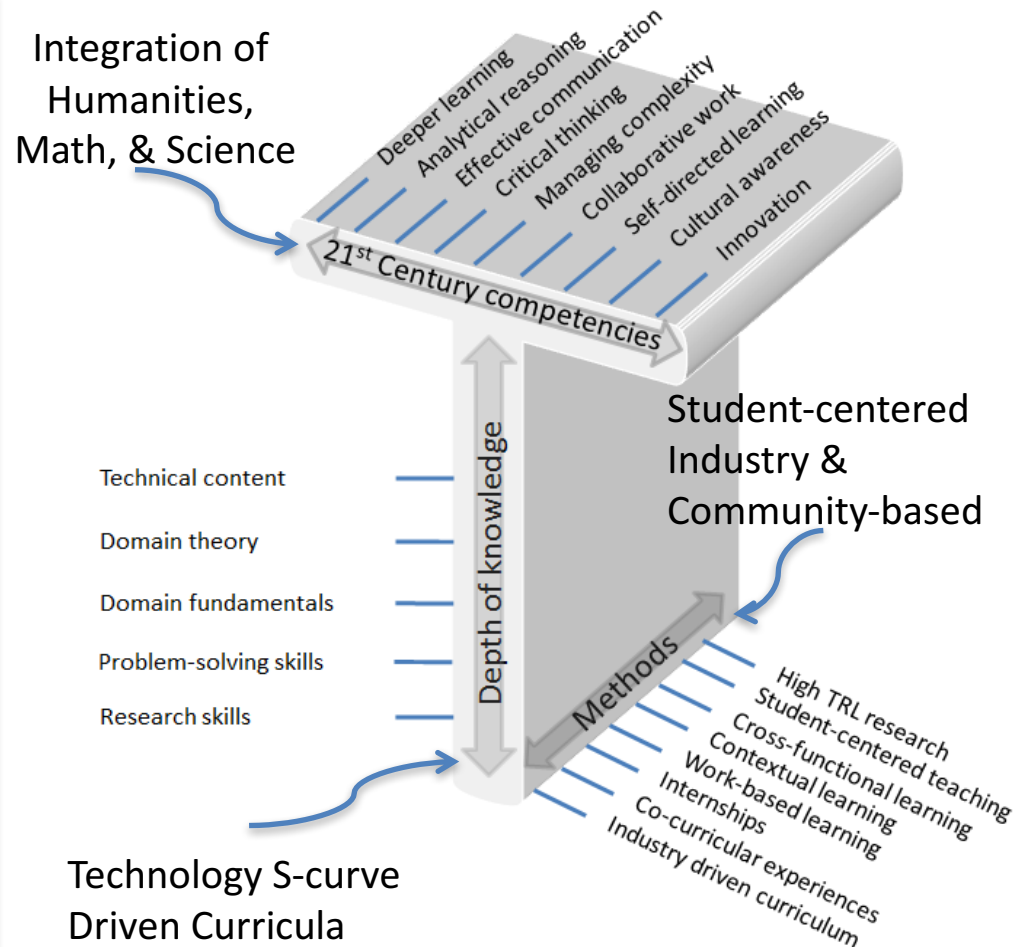
- First-year Seminars and Experiences
- Common Intellectual Experiences
- Learning Communities
- Writing Intensive Courses
- Collaborative Assignments and Projects
- Undergraduate Research
- Diversity/Global Learning
- Service Learning/Community-based Learning
- Internships
- Capstone Projects and Courses

Source: *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter* by George D. Kuh, (Washington, DC: AAC&U, 2008). For information and more resources and research from LEAP, see www.aacu.org/leap.

Preparing the t-shaped professional

Multidimensional and industry-ready

- Preparing the "T-shaped" graduate:
 - Combination of deep "vertical" knowledge in a particular technical domain with a broad set of "horizontal" skills such as teamwork, communications, competence with data and technology, and advanced literacy skills



Framing the polytechnic transformation

six areas of transformation

Special Interest Items:

- New majors
- Bold changes in construction management program
- First-of-its kind Transdisciplinary Studies in Technology Degree

Curriculum Innovation

Teaching & Learning Innovation

Special Interest Items

- Expansion of “active learning” model of instruction
- Integration of humanities studies

Use-Inspired Research



Faculty Professional Development

Special Interest Items:

- Purdue Polytechnic Indianapolis High School

K-12 STEM Education and URM Opportunity

Modernization of Learning Spaces

Special Interest Items:

- Space Requirements & Facilities Master Plan


Learning experience transformation

10 elements of transforming the undergraduate learning experience

- Areas in which we have always excelled, but are expanding
 1. Theory-Based Applied Learning (“learn by doing”)
 2. Team Project-Based Learning
- Areas that are well proven and being adopted in all programs
 3. Required Industry-Driven Two-Semester Capstone Projects
 4. Required Internships or Workforce-Like Experiences
 5. Required Globalization/Cultural Immersions
- Areas in which we aim to set ourselves apart
 6. Modernized “Active Learning” Teaching Methods
 7. Integrated Humanities and Social Science Studies
 8. Integrated Learning-in-Context Curricula
 9. Competency Credentialing
 10. Faculty-to-Student Mentoring














Teaching &
Learning
Innovation



Curriculum
Innovation

The key is to design and implement all 10 elements in an integrated synchronous fashion and not approach each component in isolation

CONSTRUCTION MGT TRANSFORMED CURRICULUM

	Estimating	Scheduling	Safety	Communications	Ethics	Soils	BIM	Const. Layout	Project Delivery	QA/QC	Legal	Sustainability	Structures	MEP		
4	Capstone #1a Industry Projects						Tech Elec	Econ	English	Capstone #1b Industry Projects				Global Elec	Comm	MGMT
3		Project #3a			Tech Elec	Gen Ed	 Project #3b 				Elect	MGMT				
2		Project #2a			Gen Ed	PHYS	 Project #2b 				Gen Ed	Science Elec				
1		Project #1a	Design Thinking for Tech	Computer Graphics	English	Math	 Project #1b 		TLI	Comm	Math					

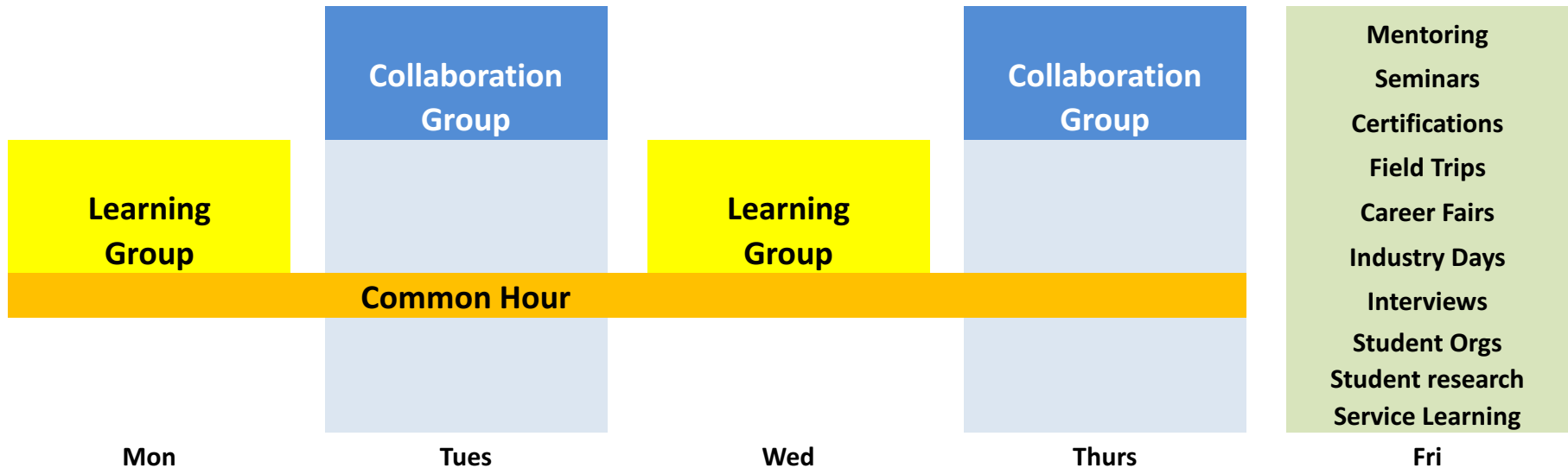
PROJECTS FOR NEW CURRICULUM – BUILDING THE LIBRARY



- Industry partners will provide all project documentation to assist with building our project library
- Projects will provide consistency and give students a common frame of reference for each course
- Potential to partner with Purdue Physical Facilities and construction projects on Purdue's campus



TYPICAL STUDENT WEEK



- All courses will be scheduled for Monday through Thursday leaving Fridays available for activities such as mentoring and job site visits
- The learning groups will bring together all of the students within a class for course activities
- The collaboration groups will divide the students into smaller sections to work more with hands-on learning tasks
- The common hour provides a time where no CM courses are scheduled to allow for items such as student/faculty collaboration and guest speakers

Polytechnic Learning Innovation

A living “incubator” laboratory to engage systemic cultural change and help inform

- higher education (Purdue Polytechnic and beyond)
- K-12 education (Polytechnic HS system)

Testing new paradigms

- Adapting to changing needs of students & employers
- Learner-centered
 - Trusting students with their learning
- Experimentation with faculty roles
 - Content creators, content mentors, assessment creators, assessors

Informed by research and experience

- Cognitive load, mastery learning, trans-literacy, transdisciplinarity, outcome-based, competency-based learning

Home of novel competency-based Transdisciplinary undergraduate program

Competency Based Education (CBE)

A combination of knowledge, skill, ability, values, attitudes, behaviors

- Integration and transfer to other settings

A showing what one can do with what one knows

Independent of seat time

Often demonstrated using combinations of artifacts and assessment techniques

- Portfolios
- Performance-based
- Student self-assessment
- Peer assessment
- Computer-based adaptive assessment

Transdisciplinary studies in technology

key milestones for new competency-based degree program

- Began experimental/pilot cohort in Fall 2014
- Gained Higher Learning Commission approval March 2016
 - Board of Trustee approval – May 2015; ICHE approval – June 2015
- Preparing to deliver to new cohort in Fall 2017
- Serves as launching point for new competency-based Engineering Technology major and others being planned

Primary Competencies (and sub-competencies)

- **Create and Innovate** (Design Thinking, Problem Solving, Entrepreneurship, Systems Thinking)
- **Engage in Culture, Values, and the Arts** (Culture Engagement, Arts Engagement, Ethical Engagement)
- **Communicate** (Written Communication, Oral Communication, Audiovisual Communication, Reading)
- **Inquire and Analyze** (Critical Thinking, Quantitative Reasoning, Inquiry, Information Literacy)
- **Interact with Others** (Individual Contribution, Give/Receive/Act on Critique, Leadership, Responds to Conflict, Active Listening)

Competency-based Education

1. Students advance upon demonstrated mastery
2. Direct and measurable learning objectives empower students
3. Assessments are meaningful and a positive learning experience for students
4. Students receive rapid, differentiated support
5. Learning outcomes emphasize creation, application, integration, transfer of knowledge

Learning is the constant: NOT Time!

Colleges and the Skill Gap

- Even the "right" credentials are not enough for the digital age.
- Graduates who do not have a certain combination of desirable skills and social capital will have a hard time finding an entry-level job and developing a career.
- Graduates who cannot effectively work on a team, communicate verbally and in writing, be a creative problem solver, learn new things, act as a drag on company productivity and profits whether they are technically qualified or not.

Curriculum Transformation

Solution

- All college students need access to experiential, inquiry-based learning.
- This will not only get them a job but also expand their minds and foster a critically thinking, well-educated electorate.
- We need to place the vocational, intellectual and civic purposes of education on equal footing.

PURDUE POLYTECHNIC HIGH SCHOOL



TRANSFORMING EDUCATION TO MEET STUDENT AND INDUSTRY NEEDS

The greatest mistake you can make is to be continually fearing you will make one.

Elbert Hubbard

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