Polymeter: Criteria and Guidelines for the Polytechnic Curricula in the College of Technology at Purdue University

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The Purdue Polytechnic Initiative (PPI) is a Purdue University Big Move focusing on the transformation of Technology Undergraduate Higher Education in the College of Technology at Purdue University and beyond. The current efforts to transform the College of Technology provides a roadmap for all of Purdue on how to respond to the challenges facing higher education in the nation. The Polytechnic Initiative promotes innovation through a set of complementary paths:

1. The Purdue Polytechnic Incubator serves as a zero-gravity space for experimenting and implementing innovative ideas outside of the normal constraints of academic structures.
2. The diffusion of incubated programs to the rest of the College of Technology (CoT) in an effort to transform Technology Education as a discipline,
3. The promotion and guidance of initiatives coming from traditional CoT Academic units. While the goal is to allow maximal diversity and freedom, all three threads are driven by the same values and principles.

1. Introduction

The Purdue Polytechnic Initiative is a values driven effort to create an exemplar undergraduate technology education of the 21st Century by questioning the assumptions underlying the current system and deriving a set of principles and guidelines that reflect the adopted values and the new science of learning and challenging underlying assumptions of STEM education in the United States. The Initiative adopts multiple parallel tracks towards achieving these goals:

1. The Purdue Polytechnic Incubator is created outside of the usual academic and administrative constraints to allow fast-tracked innovation. Faculty from all colleges but especially CoT and its strategic partners collaborate to create a new technology curriculum and experience with an accelerated cycle of creation-implementation-assessment-revision. Work done within the incubator is consistently forward looking to the next innovation and the next research question related to learning and learning environments to transform technology education.
2. PPI-Colleges diffusion. Innovative curricula and ideas tested and validated in the incubator are transitioned to the home academic units of the faculty.
3. By its very existence, the PPI stimulates innovation and encourages and challenges traditional departments. Faculty-led innovative curricula developed in the existing CoT Departments and their academic partners are measured against the criteria established in the PPI. New curricula and student experiences, aligned with the values of PPI, will benefit from PPI endorsement and support.

This paper defines the PPI values and guiding principles and defines a framework to guide the design of Technology programs that can then be endorsed and supported by PPI.

2. PPI Values

The values, assumptions and beliefs of the PPI are articulated in (Bertoline & Mili, 2013). We summarize them here.

2.1. The PPI values

PPI values every student as a <u>whole person</u> with emotional, cognitive, and social needs. It is our responsibility to support our students in developing their individual talents and sensibilities, in deepening their understanding of the world, and in gaining skills to be productive in society.

PPI welcomes students in their <u>diversity of thinking, knowing, and learning</u>. For two centuries education has favored some forms and paths of learning and knowledge over others. We equally value convergent and divergent thinking, cognitive and embodied knowing, and theoretical and experiential learning.

PPI values <u>openness, collaboration, and cooperation</u>. We value complete openness in everything we do. We value sharing and collaboration through open access to all data, knowledge, and artifacts. We value the creative powers of the communities as much as those of the individuals. We have entered an era of collective and collaborative learning, production, and consumption of knowledge. We embrace openness that underlies this communal way of working.

PPI values <u>access</u> to all students. We value access to education for all students through the nurturing and support of all talents and sensibilities. We value access to education to all students in their diversity of means, preparation, experience and backgrounds. Education beyond what is covered in the K-12 curriculum has become a necessity for the well-being of all citizens. Education beyond the K-12 and accessibility for all students is important for our society, whether it is delivered through formal institutions or not. We believe it is important to integrate formal and informal learnings.

PPI values <u>students' autonomy with their learning</u>. Learning rather than teaching is the core of education. We believe that learning is a personal act of discovery that is best fueled by strong motivations and commitments from the students. Faculty play a key role in supporting rather than driving students' learning. We acknowledge students' natural thirst for learning. Learning is most effective when it is driven by intrinsic motivation. External motivation can diminish intrinsic motivation. We see the role of the faculty as supporting the student-guided pursuit of knowledge while being mindful to support and not to counter student's intrinsic motivation.

PPI values <u>risk taking</u>. We value and believe that open-ended inquiries that have an inherent risk are keys to wholesome learning, courage, creativity, and competence.

2.2. The PPI Assumptions

Much has been learned recently about humans' motivation and learning, and much has changed about the way we work, communicate, and collaborate. In particular, the following beliefs and principles have a direct impact on the learning environments that we must provide to students.

We believe in the legitimacy of all learning. We believe that learning institutions must support and acknowledge all forms of learning wherever it takes place. PPI encourages the recognition and integration of the full spectrum of formal and informal learning.

We believe that students should be intrinsically motivated. Learning is most effective when it is driven by intrinsic motivation. Faculty can be most effective when they support student-guided pursuits of knowledge rather than inhibiting it through external rewards and penalties.

We believe that students learn best in context and for a purpose. Learning just in time (learning when needed to solve a problem), with vertical relevance (Katz, Chard, & Kogan, 2013), is more effective and more lasting than just-in-case (learning in case it comes up in a test) learning. In addition, learning is more effective when it is connected to students' values and aspirations.

We trust in students' capacity to learn and to change. As has been demonstrated by several experiments (Dweck, 2006), students' performance and self-efficacy are directly affected by their mindset. A growth mindset allows the students to persist, believe, and learn. More importantly, students can be taught to shift from a fixed to a growth mindset.

We believe that the art of learning to learn must be practiced to be mastered. One of the most important skills we help the students acquire is the ability to learn. Most accreditation agencies set "lifelong learning" as one of their criteria. We believe the process of lifelong learning is one that needs to be practiced repeatedly to be mastered. The role of the faculty is to provide the setting for this process and invite the students' reflection on what they are learning and how they are learning it. In addition, we believe that students need the practice of learning and performing individually and in communities.

We believe that individual mastery is important but not sufficient. In addition to learning individually, students need to learn how to collaborate, share, and maximize the learning and performance of their community. Collective learning also improves individual learning as students learn best from their peers.

We believe that students need to be encouraged and supported to ask big questions, address open ended problems and take risks. We believe that these are key ingredients for the intellectual growth of the students and for preparing them to be innovative and adaptable.

2.3 PPI Applied to Technology Education

The 50-year old College of Technology was created with the mission of educating practitioners in emerging technologies and technology managers, to complement other colleges at Purdue University in fulfilling the Land Grant mission. The PPI will be a renewal and extension of the essence of what the College of Technology was created to be while at the same time improving Purdue's standing as a national university. According to Robinson (Robinson, 2011), the role of education is three-fold: develop individual talents and sensibilities (**individual**), deepen understanding of the world (**cultural**), and provide skills to earn a living (**economic**). It is essential to keep an eye on all three and promote them equally. Understanding how the three interconnect is key to transforming the education system of the 21st century. Any new educational system must address all three facets at the same time. This requires

that we debunk old myths and artificial boundaries that underlie the current system. We will focus on integrated learning and learning in context. In particular, students will practice the full cycle of innovation desirability-feasibility-viability (Miller, 2010) throughout their studies.

Higher education has traditionally excelled at graduating STEM professionals with depth of content knowledge. While this is an important workforce attribute, business leaders find new graduates are not well equipped with the 21st century workplace competencies needed in today's business environments. It is the combination of the depth of knowledge and the breadth of general, transferrable skills, defined as "deeper learning" that is needed to drive US innovation (BHEF 2013). Wealth-driving business sectors are demanding workplace competencies such as analytical reasoning, effective communication, self-direction, and the ability to work in virtual and multi-cultural teams from new hires.

By design, PPI directly contributes to building an innovative workforce by incorporating teaching and learning methods that support "deeper learning" and the development of 21st century workforce competencies (Figure 1). Through purposeful university-industry partnership our graduates will be technology fluent, self-driven learners. Supported by curriculum that allows for research, exploration, work-based learning, and teamwork we are creating innovators that have already been challenged to solve the ill-structured, real-world problems that industry faces.
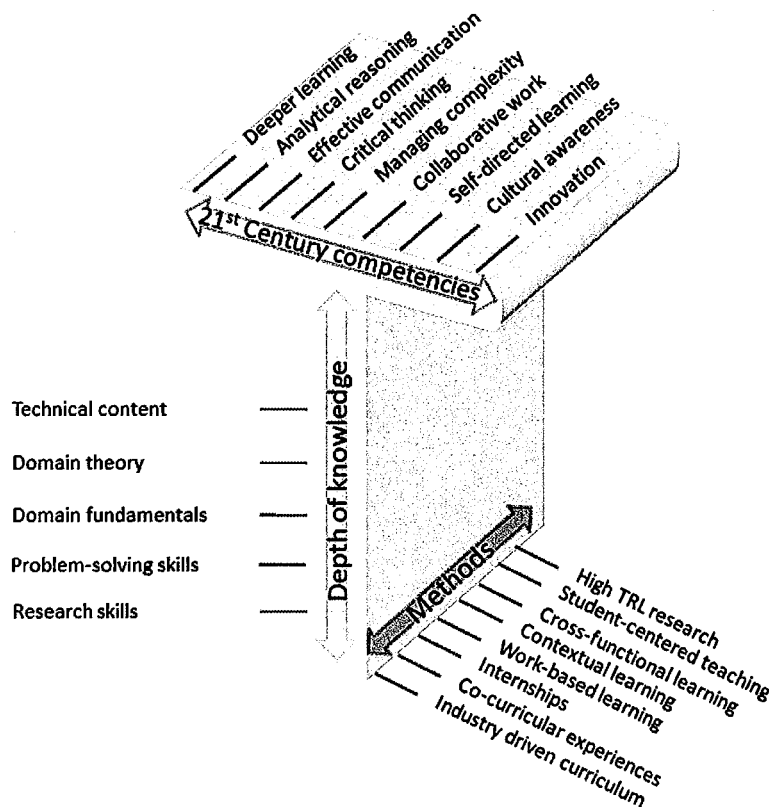

Figure 1 "T"- Shaped Professional

The following learning experiences are related to the economic role of technology higher education and are intended to be create a common core curricula but not prescriptive for some programs, which may have conflicting needs, such as the professional flight program.

- *Common Core & First-year Experience-* most degree programs and students will have a common First-Year Polytechnic Experience and the integrated experiences described below throughout their degree seeking time in the college.

- *Learn by Doing-* It is not enough to know things. PPI graduates need to be able to use their knowledge to solve difficult and important problems. Learn by Doing is the most powerful form of learning. This tradition of balancing theory with practice is embodied in our project-based undergraduate curriculum.

- *Real-world Immersive Capstone Experience (RICE)*—Yearlong industry or agency sponsored team-based senior capstone projects supervised by professors and industry or agency representatives. Some of these projects will be with companies located in outside of the US. The Real-World Immersive Capstone Experience (RICE) is one of the most innovative elements of Purdue Polytechnic Initiative's undergraduate curriculum. It requires students to work in teams to find relevant solutions to industry or societal problems using applied science and technology. Often, those problems lie well outside of their major areas. It is difficult, rewarding--and life changing.

- *Global Perspective Program-* Today's problems and opportunities are global. Students need to think globally, too. That's why PPI's Global Perspective Program is much more than a study abroad program. The Global Perspective Program is a *Study Away* program where students become immersed in another culture, domestic or international, through a semester or summer-long experience to solve a real, meaningful problem and produce results.   A *foreign language* will be required of all graduates of PPI.

- *Polytechnic Field Experience*—Semester/summer internship between their sophomore and junior years. Every PPI student has the chance to experience the kind of real-world problem solving that will soon characterize their professional careers. It's called the Polytechnic Field Experience, an engrossing, high-level design or research experience in their major field.   This program will include virtual branch campuses in large metropolitan areas where there are clusters of technology-based companies seeking interns and collaboration with the Polytechnic.

- *Applied Innovation Certificate Program*—Innovation or entrepreneurship emphasis throughout the curricula that can lead to certificates in Entrepreneurship and Innovation and Applied Innovation and Commercialization

- *Experiential Labs and Learning Labs*—hands-on learning and problem-based team projects every semester in facilities designed for collaboration and creativity. These experiences can include undergraduate research projects or student-based projects, such as Eco-Car, Solar Decathlon, EPICS, etc.

- *Technology Makers Grand Challenge Experience*-Undertaking big problems is a way of life at the Purdue Polytechnic Institute by doing things that address the issues and needs that matter most in the world. PPI students immerse themselves in solving large-scale social and technical problems from day one through the college's first-year Technology Makers Grand Challenge Experience.

- *Humanities Integration-* the humanities and arts are an integral component of the PPI curriculum and experience. Academically, the humanities enrich, broaden and engage as they prepare students for rewarding lives. The humanities also build understanding of the complex nature of applying science and technology to social issues, problems, and solutions.

- *Principles of critical thinking and logic-* critical thinking, the ability to ask hard questions, the capacity to formulate and solve problems, and the balanced judgment necessary to make decisions and choices. These skills are important for the designers, problems solvers, and leaders of business and industry in the 21st century.

- *Creativity and problem solving-* creativity and innovation are key factors not only in solving problems but also in developing new or improved products and services.

3. PPI Signature

The purpose of articulating values is to deliberately reflect on them in the learning experiences and curricula that we offer. For each value, we show features of the learning experiences that would embody it. The left side reflects the values we instill throughout the PPI experience, while the right side reflects outcomes and related values from traditional learning opportunities and experiences.

Student as a whole person	Student as a future specialized worker
• Every student is assigned a team of tutors who accompany the student on their journey. • Curricula rich in liberal art and personal development, in addition to areas of specialty. • Curricula where different topics are integrated and taught in context • Curricula provide ample choice for students	• Students enter the education system getting segmented knowledge from faculty. • Curricula narrowly focused on the specialty of the student. • Curricula focused on the economic employability of the graduate. • Curricula are rigid and fully defined.

Diversity in thinking, knowing, and learning	There is one way of thinking, knowing, and learning
• Convergent and divergent thinking are both encouraged through a variety of disciplines. Open ended problems are practiced. • Cognitive as well as bodied knowing are valued and included in the curriculum. • Formal and Informal learning as equally valued. • Infrastructure, curricula, and methods acknowledge and accommodate diversity.	• There is an emphasis on convergent thinking. Multiple choice tests. Only problems with known unique solutions are practiced. • Only cognitive knowing is seen as rigorous (theory is valued over practice). • Only formal cognitive learning is recognized and valued. • The system is designed around the needs of a narrow second of the population.

Openness, Collaboration, and Cooperation	Walled-in, Individual, Competitive
• Open classroom doors policy encourages feedback and continuous improvement. • Courses, course projects, student supervision and mentoring are all collaborative projects performed by teams. • All support and reward systems encourage cooperation for the benefit of the group.	• There is a strong ownership and protection of what happens within the walls of classrooms. • Students perform alone; they take tests in isolation; faculty work on their own courses within their departments. • Grading and evaluation emphasize personal rather than team performance

Access	Denial
• Our value is in how many students we provide access to and help succeed. • We teach students growth mindset concepts and learning to learn techniques. • Facilitate access by recognizing and credentialing all forms of learning.	• Traditional ranking systems in higher education are based on selectivity • Students are assumed to have a fixed mindset. • Only internal credits are valued.

Autonomy	Obedience
• Students have ample choice in the selection of what they learn, where from and when. • Provide opportunities for learning just in time	• Faculty choose the content, timing, and mode of learning. • Most learning is just in case.

Risk Taking	Grade focus
• Open ended problems that encourage experimentation and open-ended inquiries. • Flexibility in defining timelines for risky projects. • Assessment and "grading" that rewards innovation with its risks.	• Exercises with answers at the end of the book. Memorization and recall. • Rigid credit hour and semester time frames that everything must fit within. • Grading system that inhibits risk taking

The signature of PPI is an educational experience that satisfies all of the six values identified through the following set of high level features:

PPI Learning features and values they serve	Whole person	Diversity in thinking, knowing, learning	Openness, Collaboration, cooperation	Access	Autonomy	Risk Taking
Every student is assigned a team of faculty coaches at admission. The team remains with the student until he/she graduates	X			X		
Students have ample opportunities to drive their learning in terms of content, timing, and sources.	X	X			X	
Students are coached into balancing technical and liberal arts content.	X	X				
Students have many opportunities for integrated just in time learning through small guided and large open-ended projects.		X	X		X	X
Students have many opportunities for learning by doing		X				X
All forms of learning, formal and informal are acknowledged and valued		X	X	X		
Growth mindset and learning to learn are included in the curriculum.	X	X		X	X	
Students have many opportunities for team projects			X			X
Learning happens in chunks in different sizes and with an asynchronous fashion. Badges are given to certify learning		X		X	X	

4. Polymeter

The Polymeter is a framework for promoting the alignment of new programs with the values and principles of PPI. It is designed with an eye on evolving programs towards the PPI vision and on ensuring the alignment persists.

Student as a whole person

Aspects that contribute positively	Aspects that conflict with this value	Other aspects
• Relationship established with the student • Domain knowledge + personal development. • Integrated and in-context • Curricula provide ample choice for students	• Level of segmentation and isolated focus • Curricula narrowly focused on the specialty of the student. • Curricula strictly focused on the economic employability of the graduate. • Curricula are rigid and fully defined.	•

Diversity in thinking, knowing, and learning

Aspects that contribute positively	Aspects that conflict with this value	Other aspects
• Convergent and divergent thinking are encouraged. • Cognitive and bodied knowing are valued and included in the curriculum. • Formal and Informal learning as equally valued. • Infrastructure, curricula, and methods acknowledge and accommodate diversity.	• There is an emphasis on convergent thinking. • Only cognitive knowing is seen as rigorous (theory is valued over practice). • Only formal cognitive learning is recognized and valued. • The system is designed around the needs of a narrow second of the population.	•

Openness, Collaboration, and Cooperation

Aspects that contribute positively	Aspects that conflict with this value	Other aspects
• Open classroom doors policy • Courses, course projects, student supervision and	• strong ownership and protection of what happens in classrooms.	•

mentoring are all collaborative projects performed by teams. • All support and reward systems encourage cooperation for the benefit of the group.	• Students perform alone; they take tests in isolation; faculty work on their own courses within their departments. • Grading and evaluation emphasize personal rather than team performance	

Access

aspects that contribute	Aspects against	other
• Our value is in how many students we provide access to and help succeed. • We teach students growth mindset concepts and learning to learn techniques. • Facilitate access by recognizing and credentialing all forms of learning.	• Our ranking is based on how many students we deny. • Students are assumed to have a fixed mindset. No help is provided to those who need it. • Only internal credits are valued.	•

Autonomy

Aspects that contribute	Aspects against	
• Students have ample choice in the selection of what they learn, where from and when. • Provide opportunities for learning just in time	• Faculty choose the content, timing, and mode of learning. • Most learning is just in case.	•

Risk taking

Aspects that contribute	Aspects against the value	Other factors
• Open ended problems that encourage experimentation and open-ended inquiries. • Flexibility in defining timelines for risky projects. • Assessment and "grading" that rewards innovation with its risks.	• Exercises with answers at the end of the book. Memorization and recall. • Rigid credit hour and semester time frames that everything must fit within. • Grading system that inhibits risk taking	•

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