Early Development of a Broad Competency-Based
Transdisciplinary Engineering Technology Program

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Abstract

A newly approved degree program called Transdisciplinary Studies in Technology has started with it’s first “official” cohort of new beginners in the fall of 2017. Immediately behind is a new major called Transdisciplinary Studies in Engineering Technology slated to begin accepting students in the fall of 2018. The unique features of the program and are 1) students create their own plan of study with the help of an advisor and faculty mentor, 2) the student’s journey is highly faculty mentored, and 3) the program is competency-based. To progress and graduate, students must demonstrate their developmental proficiency of approximately 30 competencies spread across 8 broad competency families. This presentation will motivate and describe novel integrative learning experiences created to enhance competency development. The presentation will also demonstrate the early developmental work of course outcome to competency mapping and the mapping of a generalized competency assessment framework using an Engineering Technology context.

Introduction and Background

After a nearly three year development and pilot process a new competency-based undergraduate degree program was approved in March of 2016 and launched at Purdue University in August of 2017. The program, called “Transdisciplinary Studies in Technology” (TST) combines three distinct features, integrating a) student driven development of their individualized program of study, b) mentored by faculty and an academic advisor, and c) student demonstration of high level competencies. Students are expected to take deep dives into 3-4 different areas that incorporate Technology, Humanities, Social Science, and Business. The program is designed to provide intentional and repetitive learning experiences that encourage students to “connect the dots” of high level competencies with course learning outcomes, be they in traditional, flipped, or on-line modalities, experiential learning outside the classroom, and life experiences. The new major called Transdisciplinary Studies in Engineering Technology (TST-ET) is intended to serve those students who have a strong passion for the Engineering Technologies offered by the School of Engineering Technology at Purdue (Electrical,
Mechanical, Manufacturing). Students in this major would focus their technology studies in the Engineering Technology disciplines.

Traditional Engineering Technology majors typically focus a significant majority of the plan of study in deep explorations in “required” topic areas, or sub-fields. For example, in Electrical Engineering Technology students must study analog and digital electronics, microprocessors and programming, electrical power, and radio frequency communications. Similarly, Mechanical Engineering Technology students are required to study statics, dynamics, thermodynamics, hydraulics, mechanics, and materials. Students in the TST-ET program have the latitude to create a plan of study that allows space in the plan of study to make deep dives into portions of the traditional programs. For example, a student who is passionate about the Internet of Things might prefer to focus on microprocessors, programming, radio frequency communications, and materials. Another difference is that the competencies in the TST-ET program are at a sufficiently high level such that the context, or discipline specificity by which the competency is demonstrated is transcends the traditional notion of a major.

A strong motivating factor leading to the development of the TST program came from a 2013 survey of employers [2] where nearly all those surveyed (93%) indicated that “a demonstrated capacity to think critically, communicate clearly, and solve complex problems is more important than [a candidate’s] undergraduate major.” More than 90% of those surveyed said that it is important that those they hire demonstrate ethical judgment and integrity; intercultural skills; and the capacity for continued new learning. Other motivators come from sources such as Academically Adrift [1] and Creating Innovators [5] whose focus is on the need for demonstrated learning on college campuses [1] and the need to create learning environments to foster collaboration and creativity, allowing for and embracing “failure” [5].

Nearly 40 faculty were selected through an application process to participate in what would eventually become the development of the TST program in the summer of 2013. Within weeks the number of participating faculty shrank to roughly 15, whose affiliations varied widely ranging from engineering technology to theatre. These remaining faculty were exposed to a series of individual and team exploration exercises intended strengthen the bond among the participants. The initial design of two distinct learning experiences emerged in the spring of 2014. Their purpose was to examine real-world open-ended problems from different lenses. A “Seminar” experience would address the problem from a cultural and societal lens while a “Design Studio” experience would examine the problem from a science and technology perspective. The notion of “competency” was adopted through research into mastery learning, reflective learning, intrinsic motivation, and competency-based education. A competency can be thought of as the integration of knowledge, skills, and attitudes that be observed, and therefore measured, by way of a demonstration of learning. This usually takes the form of a combination of assessments and instruments.
By the fall of 2014 an initial collection of competencies was established that closely aligned with course outcomes (and credit hours) in classes such as written composition, oral communication, information literacy, and design thinking. An initial cohort of 35 first semester freshman students participated in the Seminar and Design Studio learning experiences allowing them to explore their own story of who they were (Seminar) while tackling world hunger by developing a “Garden in a Box” (Design Studio). During the spring of 2015 the faculty team decided to shift from a competency per outcome per credit hour system to a system where competencies are separate from courses. The team believed this approach leverages the benefits of utilizing traditional (and online) courses for scaffolding learning while eliminating the tractable but very large task of mapping every course outcome in the course catalog to one or more competencies.

Eight primary competency “families” were developed with each incorporating roughly three to seven “sub competencies” for a total of 42. Each sub competency is described across three developmental levels; “developing, emerging, and proficient”. The word “mastery” was intentionally omitted from our competency vocabulary as the term can be construed as a final state where no further learning is necessary or possible. These competencies are listed in Table 1.

<table>
<thead>
<tr>
<th>Competency Family</th>
<th>Sub Competency</th>
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</table>
| Design Thinking        | ● Problem Framing and Research  
                          ● Idea Fluency  
                          ● Design Options Assessment  
                          ● Managed & Iterative Design with Reflective Design Thinking  
                          ● Links knowledge from multiple disciplines to analyze and solve a problem  
                          ● Aesthetic engagement  
                          ● Unstructured Problem solving |
| Systems Thinking       | ● Ability to define the “universe” appropriately.  
                          ● Ability to define the overall system appropriately – defining the correct boundaries.  
                          ● Ability to see relationships – within the system and between the system and the universe.  
                          ● Ability to see holistically – within and across relationships.  
                          ● Ability to understand complexity – how relationships yield uncertain, dynamic, nonlinear states and situations.  
                          ● Ability to communicate across disciplines – to bring multiple perspectives to bear.  
                          ● Ability to take advantage of a broad range of concepts, principles, models, methods and tools – because any one view is inevitably wrong. |
**Effective Communication**  
Effective communication involves minimizing potential misunderstanding and overcoming any barriers to communication at each stage in the communication process.

- Written communication  
- Oral Communication  
- Audiovisual communication  
- Active Listening  
- Reading  
- Information Literacy

**Envision and Execute Independently**  
The ability of the student to see a need, conceptualize the scope of the work to be done to address the project, determine a list of tasks and appropriate timeline for completing those task.

- Lifelong Learning  
- Ensuring proper time management  
- Entrepreneurship

**Social Interaction and Teamwork**  
Demonstrate the ability to engage meaningfully with others and participate as part of a team.

- Teamwork  
- Individual Contribution  
- Proficiency in working in or directing a team with ethnic and cultural diversity  
- Working with clients and users  
- Give, receive, and act on critique  
- Collaborate in trans-disciplinary teams  
- Leadership  
- Mentoring of Team and Team Members

**Ethical Reasoning**  
Demonstrates reasoning about right and wrong human conduct.

- Developing a Global Perspective  
- Moral reasoning  
- Recognize different value systems

**Innovation and Creativity**  
Students will demonstrate innovative thinking and creativity in their work.

- Creative Thinking  
- Innovative Thinking  
- Integrative Knowledge  
- Taking Risks  
- Embracing Contradictions

**Application of Disciplinary Knowledge**  
Every student will select one or more technical areas of specialty. In order to support their development towards these areas of specialty, students will take foundational mathematics and science courses.

- Strength within one or more technical domains  
- Foundational Science  
- Quantitative Reasoning

During the next two years, with the help of students and outside sources, the team reviewed the competencies for redundant and/or confusing language that made assessment more challenging for all stakeholders than necessary. In the end, the number of competency families
was reduced from 8 to 5, and the number of sub competencies from 42 to 20. The developmental component of the competency architecture (developing, emerging, proficient) remained intact.

For example, during the pilot program from 2014-2016 it was observed that a successful demonstration of design thinking would incorporate all of the design thinking sub competencies in Table 1. Assessing design thinking would need to account for those sub competencies, and scaffolding toward the design thinking competency would need to also incorporate all of the sub competencies. Therefore the team (and the students) felt it unnecessary to separately assess each sub competency separately. Hence the design thinking competency family was integrated to a single sub competency under the Create and Innovate competency family described in Table 2. Similar logic and feedback occurred with the competency family “Systems Thinking” as seen in Table 2. Also notice in Table 2 that virtually all of the 42 sub competencies in Table 1 are represented, many by sub competency integration (Design and Systems Thinking) and several by recognizing strong similarities in the descriptions of the sub competencies and reducing two or more sub competencies to one.

Another critical aspect of the revisions to competencies was the competency language itself. The team recognized that the language in Table 1 (much of it omitted to save space) could be difficult for students, parents, and employers to process. During the period between 2015 and 2017 one of the authors was actively involved with the Competency-Based Education Network (C-BEN) [3] in drafting an initial set of principles and strategies for competency-based education programs [4]. In addition, outside competency-based education resources were consulted to review the language in Table 2 and responded positively to the new language, noting the potential to insert the words “I can” before the phrasing of each competency family in Table 2.

### Table 2 - Revised Competency Families and Sub Competencies

<table>
<thead>
<tr>
<th>Competency Family</th>
<th>Sub Competency</th>
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<tbody>
<tr>
<td>Create and Innovate</td>
<td><strong>Design Thinking</strong> - Someone who exhibits design thinking can successfully follow an established design process in order to solve problems which are open-ended, which have multiple pathways to a solution, and which require research, trial-and-error, and multiple revisions to complete.</td>
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<tr>
<td>Create and Innovate</td>
<td><strong>Problem Solving</strong> - A problem solver identifies a problem within a particular context. They propose solutions that draw from approaches from multiple domains and take into account ethical, logical, cultural and other contextual factors. They implement a solution and evaluate the results.</td>
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<tr>
<td>Create and Innovate</td>
<td><strong>Entrepreneurship</strong> - Someone who is able to understand potential needs, markets, and customers, acting on opportunities to develop solutions that they see will have value to customers or other stakeholders.</td>
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<tr>
<td>Create and Innovate</td>
<td><strong>Systems Thinking</strong> - A systems thinker can envision, describe, and analyze a system as a dynamic entity of interacting and interdependent elements acting as a whole.</td>
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</table>

A TST graduate can make creative change in the world, however big or small. You can observe, empathize, conceive, plan, execute, test, and reflect in order to solve problems, offer new artifacts and experiences, or adopt new practices.
<table>
<thead>
<tr>
<th>Engage in Culture, Values, and the Arts</th>
<th>Communicate</th>
<th>Inquire and Analyze</th>
<th>Develop</th>
<th>Explore and Create</th>
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<tbody>
<tr>
<td><em>A TST graduate can make decisions and accept responsibility in the context of values and worldviews.</em> You can recognize different values and worldviews, including your own. You can act with an understanding of the socio-economic, ecological, and cultural interdependence of global life. You can integrate the intuitive dimensions of participation in the arts with broader social, cultural and theoretical frameworks.</td>
<td><em>Culture Engagement</em> - A person who engages cultural evaluates their own and others’ cultural perspectives and values. They integrate multiple perspectives and values beyond the boundaries of their own cultural biases.</td>
<td><em>Written Communication</em> - A writer conveys messages in a tone appropriate for the purpose, genre, and the audience via text. They consider structure, word choice, formatting, mechanics, and selection of visual materials in their writing.</td>
<td><em>Critical Thinking</em> - A critical thinker examines a topic through interpretation and analysis of information from sources and synthesis of others’ viewpoints and contexts as well as their own. They develop their own position on a topic that takes into account the issue’s complexities and their own limitations, and derive outcomes and conclusions that are logical, informed, and in context.</td>
<td><em>Inquiry</em> - Someone with skills in inquiry synthesizes in-depth information from multiple, relevant sources and contexts, develops an appropriate understanding of the problem or situation, and formulates a creative or novel solution.</td>
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<tr>
<td><em>A TST graduate can make meaning by connecting people and ideas.</em> You can speak, read, write and listen clearly in person and through various medias and technologies.</td>
<td><em>Arts Engagement</em> - A person who engages with art evaluates how specific choices in the making of an object make statements within a particular culture, time, and worldview.</td>
<td><em>Oral Communication</em> - Oral communication is a presentation designed for a purpose. Oral communication skills include verbal and nonverbal techniques.</td>
<td><em>Quantitative Reasoning</em> - Someone demonstrating quantitative analysis skills reasons and solves quantitative problems from a variety of contexts and situations. They understand and can create arguments supported by quantitative evidence and can communicate those arguments in a variety of ways.</td>
<td><em>Audiovisual Communication</em> - A multimedia communicator uses audio, video, graphic, and other media to convey meaning beyond literal interpretation. They select and combine media and styles appropriate for the purpose, audience, and genre, and integrate multiple threads throughout the piece, and evaluate the effectiveness of their choices.</td>
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<tr>
<td><em>Ethical Engagement</em> - Someone who practices ethical engagement is able to evaluate different ethical perspectives and situations within various ethical frameworks, traditions, and understandings in order to determine an ethical course of action.</td>
<td><em>Reading</em> - Reading is “the process of simultaneously extracting and constructing meaning through interaction and involvement with written language.” Learners should acquire the capacity to go beyond simple literal comprehension. They should be able to infer implicit meanings, allusive points, and discern the direction of an argument or narrative. Learners should develop analytic skills for textual and narrative interpretation and critique and for self-education.</td>
<td><em>Audiovisual Communication</em> - A multimedia communicator uses audio, video, graphic, and other media to convey meaning beyond literal interpretation. They select and combine media and styles appropriate for the purpose, audience, and genre, and integrate multiple threads throughout the piece, and evaluate the effectiveness of their choices.</td>
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methodology for inquiry, and analyzes evidence to reveal insights. They draw logical conclusions and discuss relevant limitations of the inquiry and its implications.

- **Information Literacy** - Someone who is information literate understands that artifacts and ideas inform and are informed by others’ artifacts, attribute others’ ideas and artifacts when necessary, and search effectively and efficiently for ideas and artifacts in their work process.

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<tr>
<th>Interact with Others</th>
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<tr>
<td><strong>A TST graduate can make valued contributions to groups of people, organizations, or society more broadly.</strong> You can navigate a group environment in order to better the functionality of a team, including listening to the views of others, reconciling disagreements, and assuming leadership roles when needed. You must demonstrate an ability to give and receive critique with others in order to help reach meaningful conclusions.</td>
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<tr>
<th>Individual Contribution</th>
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<tr>
<td><strong>An individual contributor makes a meaningful contribution to the group, bringing in one’s own strengths and disciplinary background; offers alternative solutions or courses of action that build on the ideas of others; and completes tasks by deadline.</strong></td>
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<tr>
<th>Give, Receive, and Act on Critique</th>
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<tr>
<td><strong>Someone who can give, receive, and act on critique can respectfully give meaningful critique to others, can accept critique openly, and can make thoughtful decisions on whether and how to apply critique they’ve received.</strong></td>
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<th>Leadership</th>
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<tr>
<td><strong>A leader observes and influences others to accomplish the mission in ways consistent with the values of the organization, holds others accountable to meet goals and objectives, and provides the support necessary to achieve desired objectives.</strong></td>
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<tr>
<th>Responds to Conflict</th>
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<tr>
<td><strong>Someone who responds to conflict encourages creative tension and differences of opinions as opportunities for productive discussion, and anticipates and takes steps to prevent counter-productive confrontation. They listen openly, take into account others’ perspectives and their own role in the conflict, and engage in strategies to recognize, diffuse, and address the situation.</strong></td>
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<th>Active Listening</th>
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<tr>
<td><strong>An active listener comprehends the meaning spoken by another. They signal understanding verbally and nonverbally, and are able to respond with empathy to nonverbal cues to elicit more information from the speaker.</strong></td>
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**Outcomes to Competencies**

The TST-ET major uses the same competencies as the TST program it resides under. The list of competencies is in transition as of this writing, and we are using the forward-looking competencies and their descriptions found in Table 2 as those to map from course learning outcomes. During the summer and fall of 2017 the authors have been examining the learning outcomes from every engineering technology course offered by the School of Engineering Technology. In the interest of conserving space we focus on the first program examined which is the Mechanical Engineering Technology (MET) program.

Course learning objectives and outcomes (CLOOs) for 40 undergraduate courses in the Mechanical Engineering Technology program (MET) were mapped to 20 competencies. A
learning objective was mapped to a competency only if an explicit statement of the objective matches with the description of that competency. The result is shown in Figure 1, which gives the count of courses that have at least one learning objective mapped in such a manner. It should be stressed again that only written CLOO statements are surveyed. In reality, many courses imply development of certain competencies through assignments and assessments. The issue is that current CLOOs are developed around topics and concepts that are important for the given course, rather than what competencies that are needed to master certain topic. Hence, implied competencies needed to master a certain topic or concept are not transparent. The situation is aggravated by the use of generic action words, like “analyze,” “understand,” and the like.

Some competencies however, have overarching presence in the vast majority of surveyed CLOOs. They belong to the broad families, Create and Innovate, and Inquire and Analyze. Refer to Figure 1. Virtually each course has problem solving and critical thinking in more than one learning objective, which is expected noting the technical nature of the program. Each course requires the student to understand how the concepts fit in a broader picture, which is the systems thinking competency. Almost all courses, 37 out of 40, state quantitative thinking. Those 3 that are not counted just did not explicitly state that competency, although from our personal experience they include quantitative reasoning. Design thinking is also underreported. One example is MET 213, where students design, build, and test a catapult. This team project is open-ended and there are many possible design solutions. Students iterate their designs until they make a catapult that functions properly and according to calculations. However, this course is not credited with design thinking and team work, because its CLOOs does not state that.

A significant number of courses include optimization of design, materials, or processes in order to maximize quality and profit. In that sense, they could be loosely related to entrepreneurship. Nevertheless, only one course is granted entrepreneurship competence because its learning objective is stated in a way that matches the definition of this competence.

The number of courses counted to develop competency to communicate underrepresents the true state. Laboratory exercises and laboratory reports are staple activities of the MET program, yet they are not mentioned in many CLOOs for courses. Almost every course develops and assesses written communication competency through laboratory reports, but only 8 of them declare oral presentation and 13 written presentation of results as one of their CLOOs. “Drawing graphs and diagrams,” which is found in CLOOs of 27 courses, is mapped to the “audiovisual communication” competency. Although it might be obvious to classify graphs and drawings as a written communication competency, because it is implied that they are integral part of written reports, we opted not to do so.

Similar to communication, team work on projects is not widely reported. Only 7 courses mention team work in their CLOOs, although large number of courses implement a final project
that is done in teams. Even when reported in CLOOs, one cannot discriminate separate competencies within the family Interact with Others, so all courses that declare team work are credited with only “individual contribution.”

One competency family that is not well developed is Engage in Culture, Values, and the Arts. Ethical behavior is implied in many courses, but not discussed intentionally nor assessed in a systematic manner. MET 214 Machine Elements is a rare example where an outcome explicitly states “demonstrate skill and commitment to accurate work…” MET 220 Heat Power adds a social component with “understand professional, ethical, and social issues and responsibilities.” MET 144 Materials and Processes II includes philosophy of green manufacturing in its CLOO, which implies development of ethical and social competencies, but without explicit statement in CLOO. Those three courses are assigned as those that foster ethical engagement.

CLOOs of courses in their current state are concentrated on topics themselves, rather than competencies needed to achieve mastery level in these topics. Although development of certain competencies is implied in order to succeed in the course, those competencies are obscured and are a challenge to be identified. In order to achieve transparency of competencies, CLOOs should be rephrased. The most important reason is that they can become formal part of curriculum only if they are developed and assessed in a planned and systematic procedure. For that reason it is important to rephrase CLOOs so they contain unequivocal definition of competencies and how they relate to the topics and concepts relevant to the course. That will inevitably influence both the content delivered and the method of delivery. It is also important to understand that courses do not have to foster each competency. Rather, curriculum should be tailored in such a way to provide students with balanced set of competencies.
Learning Experiences

Students in the TST program and TST-ET major must take two TST courses each semester. One is a 0.5 credit hour course intended to provide the student with coaching and individual feedback as they create their portfolio of work that demonstrates their developmental level across the competencies. The other is a combined studio/seminar course that can take on a variable title and variable credit, from 4 to 8 credit hours. The idea here is to provide intentional opportunities for repetitive “practice” of each student’s individual educational journey. Each
course is facilitated by a minimum of two faculty, each from widely varying fields, resulting in a "transdisciplinary" approach to problem-solving. Alongside the required courses, the students will be crafting their plan of study while selecting from technological studies to liberal arts, roughly two thirds of their program of study.

As the student's progress through the curriculum, they are exposed to issues of expanding scope, complexity, and impact. They also vary in the degree to which each student works in a team versus individually. This is to provide them with the skills and knowledge to help them prepare for their senior year (when they set upon a real, unstructured problem in a year-long capstone experience). Each semester from freshman through junior year, they will have an issue/problem to address and they are to design and prototype a solution. While it is not expected that every student will exist in their professional lives at all of these levels, the students will have this exposure and can use the knowledge, skills, and attitudes (KSA’s) they practice and develop to help them become better problem solvers with anything they could come across.

Projects below in Table 3 are examples of those being considered for development alongside appropriate critical thinking curriculum in the studio/seminar course. It is expected that several projects will be developed over time such that they are selectable by the student or student teams, stimulating the intrinsic motivation of each student.

<table>
<thead>
<tr>
<th>Semester</th>
<th>Description/Project</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to different ways of observing the world, learning how to scope a small and familiar object's design. &quot;Ways of Knowing&quot;</td>
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<td></td>
<td><strong>Project:</strong> Design or redesign a small item inside a space (e.g. a slide in a playground)</td>
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<td>2</td>
<td>“Describe your space”</td>
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<td></td>
<td><strong>Project:</strong> Design the space that the previous object existed in (e.g. the playground)</td>
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<tr>
<td>3</td>
<td>Community &quot;Knowing the neighbors&quot;</td>
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<tr>
<td></td>
<td><strong>Project:</strong> Design the community that surrounds the space from the prior example (e.g. neighborhood around the playground)</td>
</tr>
<tr>
<td>4</td>
<td><strong>Project:</strong> Re-design or design the city/region that the community is a part of (e.g. small scope civic planning)</td>
</tr>
<tr>
<td>5</td>
<td><strong>Project:</strong> examine the politics / culture of the country / large geographic region. Examine the prior semester's work and adjust based upon the new information learned.</td>
</tr>
<tr>
<td>6</td>
<td><strong>Project:</strong> Global politics / culture / economics, examine all of the projects to this point, re-design to find either universal solution or path to solution and manufacture.</td>
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</tbody>
</table>
Discussion and Future Work

As mentioned in the section on competency mapping, outcomes based on topics can make for challenges when trying to assess higher order competencies like critical thinking, quantitative reasoning, and information literacy. Competencies like teamwork are often implied and not explicitly stated, giving rise to the rigor of their assessment. Competencies, their descriptions and criterion for success are precisely stated to be understandable by the students, their parents, employers, and faculty. Assessment frameworks and methods require rigorous forethought and design so as act as a learning tool rather than solely a means of judgement.

The required learning experiences described above are intended to assist in providing competency scaffolding (traditional courses are supposed to do much of this) and more importantly, connections between course(s) outcomes and competencies. They also provide a safe space for students to re-learn how to iterate. How did we learn to walk, or talk? Competency assessment is intended to be real-time, and developmental. The learning experiences are intended to provide a place for students to “practice” with access to transdisciplinary faculty experts serving as “guides on the side”.

One fact of the program not deeply discussed in this paper is that of the portfolio required by each student. The portfolio is intended to serve as their first major artifact that they can share with potential employers as a means of demonstrating what they can do with what they know – showing their competencies and how they connect. Since each student creates her own plan of study, each portfolio is intended to tell the student’s individual story of who they are.

The designers of the TST-ET major are working closely with the designers of the TST program to further refine the mappings of course learning outcomes to competencies. A second, and possibly third pass at the mapping activity is occuring at the time of this writing. The team is also working on the development of the assessment framework to provide students with the best possible formative and summative feedback as they demonstrate competency. We expect to admit new beginners into the new TST-ET major in the fall of 2018.
References


Biographical Information

JEFFREY J. EVANS is an Associate Professor in the School of Engineering Technology in the Purdue Polytechnic Institute. As a founding Polytechnic faculty fellow, he is interested in learning innovation and spearheaded the development, approval, and launch of Purdue’s first competency-based undergraduate program. Dr. Evans also works in the areas of distributed computing and artificial intelligence (AI), focusing on the use of AI in music composition and performance.

DAVIN HUSTON is an Assistant Professor of Practice in the Schools of Engineering Technology in the Purdue Polytechnic Institute. He is interested in hearing assistance systems, motion capture, and audio/video transport networks. He is a founding Polytechnic faculty fellow and is also interested in competency-based education and was instrumental in the development of the Transdisciplinary Studies in Engineering Technology major.

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