Developing cross-cutting competencies for a transdisciplinary world:  
An extension of Bloom’s Taxonomy

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Abstract

This chapter presents an adaptation of Bloom's Taxonomy as part of a framework for facilitating the development of cross-cutting competence to prepare well-rounded professionals. This framework moves away from discipline- or content-specific learning to focus on skills that are relevant across disciplines, and that encourage synthesis across disciplines and movement towards thinking beyond disciplines. The extended Bloom’s taxonomy and competency framework was developed for a transdisciplinary undergraduate degree program, but it could be used or adapted for the needs of other programs.
Developing cross-cutting competencies for a transdisciplinary world: An extension of Bloom’s Taxonomy

Globalization and technological innovations continue to lead to the creation of new roles and expectations for recent graduates. To compete in today’s job market, new graduates must be prepared to go beyond discipline-specific competence and become skilled in communication, critical thinking, problem-solving, ethical judgement, teamwork, intercultural skills, and lifelong learning (Hart Research Associates, 2013; Messum et al., 2017; Nae, 2017), as well as demonstrate the ability to solve problems with solutions spanning traditional disciplinary boundaries (Bridle et al., 2013; Holley, 2017; Palmer, 2001; Repko, 2008). Yet, employers indicate that graduates often lack these skills (Hart Research Associates, 2013; Messum et al., 2017).

Interdisciplinary education is an effective way to help students develop creativity, innovation, and synergy while crossing disciplinary divides (Haynes, 2017). Interdisciplinary education is an umbrella term for a range of activities that disrupt disciplinary silos (Holley, 2017; Lattuca, 2001). It exists along a continuum from cross-disciplinarity, where educational experiences are designed to combine neighboring fields, to transdisciplinarity, which allows students to synthesize multiple fields and develop their own conceptual frameworks (Klein, 2010; Rosenfield, 1992). Higher education often touts interdisciplinarity integration (Cooper, 2012). However, there are challenges to the process of meaningfully integrating multiple disciplines, including the need to restructure the learning process and implement teaching and learning strategies that ensure students develop interdisciplinary skills (Klein, 2005; Stozhko et al., 2015). For students to effectively achieve either program-specific or personalized goals, interdisciplinary competencies (or a combination of knowledge, skills, abilities, and attitudes) need to be clearly defined.

Program designers must consider the complexity of learning, since new competency acquisition is built on previous knowledge to ensure that skills and knowledge “develop and become integrated with other behaviors to form more complex behavior which is classified in a different way” (Bloom et al., 1956, p. 10). Bloom’s Taxonomy, a classificatory model for curriculum and performance-based objective development, is a popular model for ensuring higher order levels of learning (Darwazeh, 2017). Bloom’s Taxonomy, as revised and fine-tuned by Anderson et al. (2001), provides a hierarchy of six levels: remembering, understanding, applying, analyzing, evaluating, and creating. These are intended to emphasize “what learners know (knowledge) and how they think (cognitive processes)” (Anderson et al., 2001, p. 38). While well-known in education, the original Bloom’s Taxonomy and Anderson’s revised version have a number of limitations that should be considered in the design of educational experiences. The hierarchy and single dimensionality of the taxonomy appear to presume that learning is linear and moves from simple to complex behaviors (Furst, 1994; Darwazeh, 2017). Yet, some aspects of knowledge at the lower level may in fact be more complex than those at the top of the Taxonomy’s hierarchy (Krietzer et al. 1994; Soozandehfar & Adeli, 2016).

The goal of this chapter is to explore the applicability of Bloom’s Taxonomy to a transdisciplinary, competency-based undergraduate program, and how modifications to the Taxonomy might make it more suitable to such a setting.

Program: Transdisciplinary Studies in Technology

The Transdisciplinary Studies in Technology (TST) undergraduate program at Purdue University is a novel competency-based transdisciplinary program whose intent is to bridge the gap between higher education, the needs of the 21st century labor market, and the whole-person focus of liberal arts education. Instructors include faculty and staff from across disciplines. Students in this program build a unique transdisciplinary identity by creating an individualized plan of study that includes a set of core courses as well as courses in self-selected focus areas, at least one of which must be technical and one liberal arts-based. Core TST courses combine a
design studio model with seminar-style discussions, where students are expected to begin designing from day one. Students can take the remainder of their courses from any department in the University. This program was piloted starting in 2014, and was approved as a degree-granting program in 2016.

A key aspect of the program is the acquisition of cross-cutting competencies (otherwise known as “21st century” or “professional” skills) to prepare students for "jobs that do not yet exist, to use technologies that have not yet been invented, and to solve problems that we don’t even know are problems yet” (Darling-Hammond et al., 2008, p.2). This requires a well-designed competency model that goes beyond discipline-specific knowledge and skills to help students develop into well-rounded individuals with unique transdisciplinary identities. The TST competency model was intended to ensure that students develop a strong foundation in the skills that are important across disciplines, such as critical thinking, communication, problem solving, and ethical engagement. Designing such a competency model is challenging, as it must be discipline-agnostic, while providing clear, measurable definitions and well-defined relationships among competencies that outline the progression towards mastery. Aligning with the transdisciplinary program vision, students are required not only to demonstrate competence in their disciplinary focus areas, but also to demonstrate the ability to apply, transfer, and ultimately integrate traditional disciplinary knowledge and practice into their own novel work.

**History of Competency Model**

The program has undergone several iterations since the pilot, including the evolution of the competency language. The initial competency model included 42 competencies, comprising three levels each to reflect the evolving proficiency of student knowledge, skills, and abilities. Where possible, competency language was adapted from the Association of American Colleges & Universities (AAC&U) VALUE rubrics and other existing sources. A central concern was to ensure that the competency language was sufficiently flexible to account for disciplinary differences and applicability to project work; student badge submissions could range from engineering projects to topical exploration through the lenses derived from disciplines such as history, philosophy, or gender studies. Competency levels were credentialled using digital badges, awarded once competence was exhibited at each level through submitted artifacts. Pairs of mentors were tasked with reviewing submissions and awarding badges.

Faculty and students soon began expressing concerns. Faculty indicated that assessment was time consuming, while students found the language confusing and assessment to be subjective and inconsistent. The types of knowledge, skills, abilities, and level of difficulty constituting the three competency levels were also inconsistent across competencies.

Several additional rounds of revisions and refinements were made to lower the number of competencies and develop more consistent language. During this process, the competency sub-committee began to use Bloom’s Taxonomy as a foundation for a framework to promote consistency across each competency level. However, the Taxonomy had limitations. Its implied hierarchy of levels did not align well with our design-centered pedagogical model, in which students build and create from the start. It also lacked language specifically related to our transdisciplinary approach. While rules were developed to move towards language that was clear, devoid of academic lingo, and could be understood by high school students, parents, and employers alike, the clarity and transparency expected for a CBE program was still missing.

Therefore, in fall 2017, work on the competency model resumed. A new iteration of the model included simplification of competency language and creation of behavioral indicators (BIs). BIs refer to specific tasks students must perform for the competency level to be credentialled. BIs allow for transparency and objectivity among both students and assessors. A framework based on the modified Taxonomy was used to create both the BIs and the revised competency language (see Figure 1). Additionally, “I” language was adopted to help students internalize the work they need to do and the level of mastery to be achieved. The model and sample competencies were reviewed by the larger faculty team, all of whom had been involved in writing
prior versions of the competency language and had assessed competency submissions in the past. Modifications were made to the framework based on the group’s discussions.

To ensure internal alignment and the alignment with the extended Taxonomy, as well as student workload for each level, all levels were compared with each other vertically (within one competency) and horizontally (across the same level of all competencies developed to date). A list of active verbs for each level was identified and some language was modified to ensure this alignment. Revised competencies were reviewed by the teaching faculty and will be evaluated by external peers and students to ensure that the language is friendly and clear.

**Transdisciplinary Bloom’s Taxonomy**

Figure 1 represents the most up-to-date framework, which includes three main phases (developing, emerging, and proficient), as well as a foundational level. While it maintains the general hierarchy of the Bloom’s Taxonomy, some of the Bloom’s levels are repeated across phases. Students will be expected to demonstrate lower level BI’s in their subsequent work.

![Fig. 1. Extended Bloom’s taxonomy](image)

A detailed description and sample of each competency level is given below:

**Foundational:** While the foundational level is not part of the competency model, it reflects the benchmark level that a student should have prior to working on competency acquisition. In general, students should have gained the foundational level in high-school or early during their university core courses. Students not meeting the benchmark may need to consider taking remedial courses or informal/non-formal learning opportunities to ensure their readiness.

**Developing:** This level provides a well-scaffolded opportunity for students to engage in the competency. The requirements vary based on the competency description. Generally, students perform actions such as defining, comparing, describing, explaining, and planning. Any of the developing-level competencies can be achieved within project(s) undertaken in a TST course (typically a design or inquiry project) or in a university core course. In the example below (Table 1), students must first identify what constitutes ethics and how ethics may be at play within disciplinary perspectives or professional fields, then they apply their findings to a current project or experience.

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<tr>
<td><strong>Competency Description/Statement</strong></td>
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<td><strong>Ethical Engagement, Developing Level: Competency Description and Behavioral Indicators</strong></td>
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<td><strong>PROFICIENT</strong></td>
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*Fig. 1. Extended Bloom’s taxonomy*
It is important to note that at this stage, students are applying disciplinary knowledge from a single field; this focus allows students to develop insights and understand limitations prior to attempting to integrate other fields (Boix Mansilla & Gardner, 2007). For ethical engagement, students may use insights from an introductory philosophy, social scientific, professional, or technical course to begin identifying and defining ethical frameworks that may be relevant to a dilemma (e.g., considering when and how it is appropriate to use data collected from human subjects) or project (e.g., considering ethical implications of manufacturing a product).

Emerging: At this level, students learn to make use of knowledge, skills, and abilities across at least two fields or disciplines to solve problems. These problems are situated within students’ project or design work in TST courses, outside courses, or extra-curricular opportunities. The active verbs at this level, such as analyze, propose, test, devise, support, and reflect, allow students to engage intentionally with the skills and abilities foregrounded in each competency. Students will begin to transfer insights from one discipline to another or combine insights from two or more of the disciplines they identify as important to their project. In the ethical engagement competency, students will have already defined ethics and identified an ethical framework that is relevant to their work at the developing phase; now they will analyze multiple different ethical frameworks and allow their understanding of these frameworks to analyze options they are considering taking in their own project work (Table 2).

Table 2

**Ethical Engagement, Emerging Level: Competency Description and Behavioral Indicators**

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<tr>
<th>Competency Description/Statement</th>
<th>Behavioral Indicators</th>
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<td>I analyze how two ethical frameworks or sets of ethical guidelines might approach a problem, action, or dilemma I am facing. I propose two or more possible courses of action for my problem and analyze the ethical implications of each.</td>
<td>1. I analyze how two ethical frameworks or traditions, or sets of ethical guidelines, might approach a problem, action, or dilemma I am facing. 2. I propose two or more possible courses of action for my problem. 3. I analyze the ethical implications of each of these courses of action, utilizing research and ethical tools from two or more disciplinary areas or professional fields.</td>
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Proficient: By now, students should be ready to fully engage in transdisciplinary thinking by integrating insights and approaches from multiple disciplines and developing new ones. Students are also encouraged to engage with community and other stakeholders to create new or shared conceptual frameworks that go beyond disciplinary boundaries (Choi & Pak, 2006; Holley, 2017; Klein, 2010; Lattuca, Voight, & Fath, 2004; Rosenfield, 1992). The use of active verbs in the behavioral indicators once more reflects this level, e.g., justify, organize, revise, solve, critique, and enhance. Again, the design-oriented pedagogy of the program presupposes that this work is taking place during the course of building, creating, and designing during project work; at the proficient level (during which most students will be in their third or fourth year in the program), this work will be increasingly independent and self-directed.
Our proposed model extends Blooms in several ways.

**Transdisciplinarity**

For students to develop transdisciplinary thinking, they need to acquire a range of cognitive subskills (Van Merrienboer, 1997), including establishing a purpose and weighing and integrating disciplinary insights while maintaining a critical stance (Boix Mansilla, 2010). However, this process takes time, as it may be challenging for students to not only combine two disciplines when developing their artifacts, but also integrate disciplinary or interdisciplinary insights and/or create their own (Spelt, Biemans, Tobi, Luning, & Mulder, 2009). Lattuca, Knight, and Bergom (2013) suggested key considerations for interdisciplinary or transdisciplinary thinking that are reflected in our framework: establish awareness of disciplinarity; appreciate disciplinary and non-disciplinary perspectives, recognize disciplinary limitations; evaluate critically through an interdisciplinary lens to find common ground; use reflexivity to understand own biases and other limitations while synthesizing disciplines and, finally, synthesize disciplines by taking in insights from relevant areas to inform solutions that, as suggested by Newell (2001), would be incomplete if viewed through a single discipline lens.

This process is scaffolded across all three levels of the competency model, in order to give students the time to acquire and develop these skills. At the developing level, the focus is on establishing an awareness of disciplinarity and appreciating disciplinary and non-disciplinary perspectives. At the emerging level, students begin to recognize disciplinary limitations and to compare, contrast, combine, and/or transfer knowledge, skills, and abilities across disciplines to solve problems using more than one disciplinary lens. Finally, at the proficient level, students develop novel solutions by integrating disciplinary insights. However, the language used in BIs must be flexible enough to allow for the assessment of artifacts that showcase higher-order skills, including those practiced during project work, design work and collaborative projects (e.g., Biasutti, & El-Deghaidy, 2015); experiential or service learning projects (e.g., Rooks & Winkler, 2012); reflections on learning and (e-)portfolios (e.g., Wang, 2009); and self- and peer assessment (e.g., Hersam, Luna, & Light, 2004), among others.

**Creative Work**

As described in Exter, Dionne and Lukasik (2015), this program was designed around a spiral model that incorporates humanities-inspired seminar and design studio instruction. Students begin engaging with creative work from day one, fostering praxis through a combination of practice and theoretical engagement, and the opportunity to learn theory through learning-by-doing, critique, reflection, and just-in-time learning (Varner, Gray & Exter, this volume). While initial projects are heavily scaffolded and have a relatively limited scope, students are expected to engage fully in the design process and reflect on their own practice. Therefore, it is
inappropriate for students to be limited to the lower levels of Bloom’s, which focus on remembering and understanding information rather than developing new skills and abilities.

Knowledge Dimension

Our framework reflects a knowledge dimension, in which students proceed from factual to abstract knowledge (Anderson et al., 2001). This allows students to learn how to learn and guides them in the development of lifelong learning as a habit of mind and key component of professional practice. Students demonstrate metacognition by reflecting in writing on how their artifacts, such as design projects, written essays, or group work, meet the behavioral indicators for each competency. These artifacts are evaluated by faculty mentors to ensure the growing depth and breadth of students’ knowledge and skills and their alignment with the competency model.

Challenges and Practitioner Implications

We have combined these two sections, as understanding potential challenges can help avoid or address them in the future.

- **Be aware of the time it takes:** The process of developing and refine a competency model requires significant time and effort. The initial set of competencies was developed in a relatively short amount of time, and many problems were found once they were put into place. Recognizing the need to take a step back and create a framework to guide the process allowed us to better conceptualize and standardize the competency language and required BIs. This design process was complicated and required high level input from multiple team members across multiple rounds of collaboration and revision.

- **Engage disciplinary expertise to ensure appropriate, high-quality cross-cutting competencies:** Although each competency is intended to be cross-cutting, we have found the need to engage disciplinary subject matter experts and existing sources (such as the AAC&U rubrics) for individual competencies to ensure that each level has the appropriate level of difficulty, and that each BI is relevant and applicable to the performance expectations we intend to address. For example, our team member with a background in English studies led the design of the written communication competency to ensure that concepts and terminology used in the developing and emerging levels were consistent with those used in Purdue’s core English courses and that proficient-level BIs represented what would be expected from a sophisticated graduate of a four-year degree.

- **Be aware of bounded disciplinary lenses:** Being a professional in a specific field often creates disciplinary lenses or boundaries. Program designers and instructors may find it challenging to cross boundaries due to disciplinary differences or lack of readiness (Baker & Daumer, 2015; Kandiko, 2012; Reynolds, 2012). We have found that the best approach was to discuss each competency in depth in person, both within the project team and with other members of the program. Initial conversations may not necessarily bring disciplinary differences to light, as we often use language differently. Therefore, multiple extended conversations are necessary. While it takes additional time, this step allowed us to ensure that the language used and the expectations are clear and meaningful for all.

- **Align the language:** This is a multi-layered challenge. We had to ensure that the language is clear for all stakeholders, including students, parents, faculty, assessors (who may or may not be faculty), and potential employers. Each competency description and BI was discussed in full to minimize unintended ambiguity, including the use of discipline-specific terminology. A glossary was written to address the need for more complex language when necessary.

- **Gain the buy-in of all involved from early on:** Our early attempt to align competencies with the revised Bloom’s taxonomy did not result in the level of consistency across competencies and assessments that we anticipated. We suspect this was because we failed to elicit buy-in from all involved. Faculty who were not members of the competency...
design team may not have realized the arduousness of the process or the importance of work, or the need to use a framework to maintain consistency across competencies and competency revisions. This resulted not only in significant lost time, but also some hard feelings across the larger group. Therefore, in the current phase of design, we have elicited feedback and expertise from the larger team early on.

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