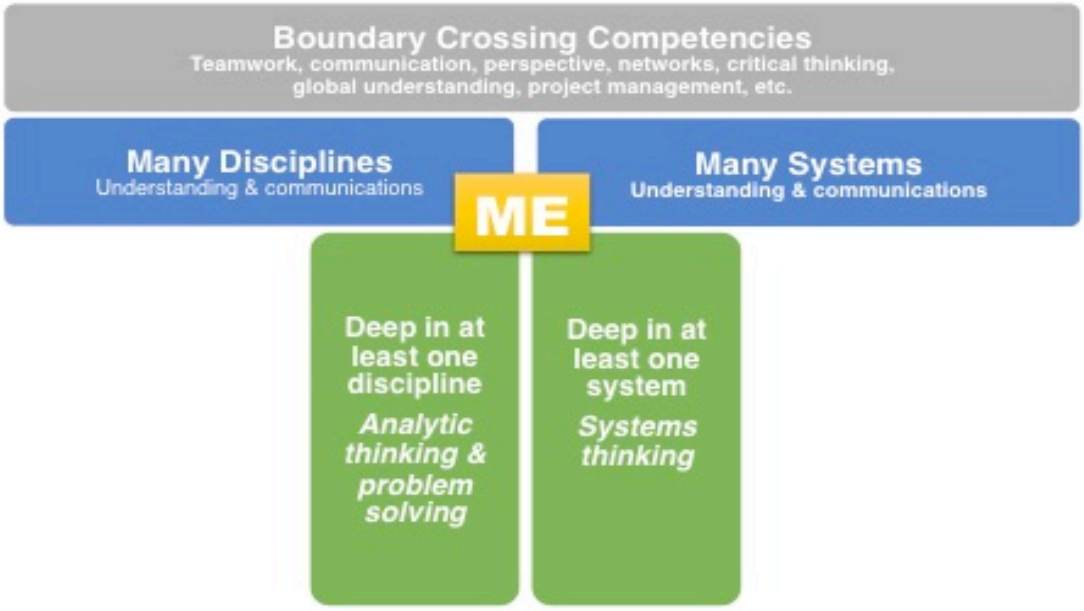
A Primer on the T-professional

Phil Gardner, PhD
Director
Collegiate Employment Research Institute
Michigan State University

Doug Estry, PhD
Professor
Michigan State University



What is a T-professional?

The T-professional, often illustrated as a large block T, integrates depth, defined in terms of disciplinary knowledge and the ability to understand how individuals with that knowledge function and interact to accomplish a desired outcome within or across a system(s), and breadth, defined as the professional abilities that allow someone with profound disciplinary knowledge to interact meaningfully with others who possess different disciplinary knowledge in order to affect an outcome that might not otherwise be possible. The T-model provokes a conversation on the degree to which innovative approaches to learning design encompasses alternatives for shaping and aligning the talent between the higher education experience and post-graduation opportunities. Enthusiasm for the potential for the T to serve as a constructive model around the design of visionary new models of curriculum and learning, coupled with the application of evidenced based practices for teaching and learning emerged from a collaboration between Michigan State University and IBM.

Three successive T summits gathered industry and education professionals to discuss the T-model. Throughout the summits, a concern arose that the discussions failed to establish a common language for the components of the T and a foundation of core T-principles. Even with a venue allowing participants to share differing mindsets, vocabulary, and definitions, the cacophony surrounding discussions only added to the confusion. Up until this moment, the discussion only superficially addressed the T and its components; little thought focused on the underlying research and support that defines each of the T-components and the T-model in whole cloth. Therefore, the purpose of this monograph is twofold. First, it provides an historical perspective that weaves together the various singular threads that guided the authors and their colleagues to advance the T as an important educational mindset. Second, it provides supporting research that underlies our attempt to add substance to the definition of the individual T-components. The T-model does not merely mean adding professional abilities and work-based experiences to the curriculum and calling it good. As a model, the T requires the innovative and intentional use of technology, space, and context to design learning experiences that can be integrated to chronicle a learner's development into a T.

The Context for Defining the T

During the last 25 years, the economy has been undergoing major transformations. In the early 1990s, the economic changes appeared to be no more than gentle and manageable breezes. Ten years later the winds of change became gale force propelled by the convergent forces of an easily accessible global workforce, reduced friction in global financial transactions, and rapid advances in labor saving technologies (see Smil, 2013, for example). American workers, both blue and white collar, found themselves unprepared for the rapid shift in employment options. Employers did not simply eliminate or outsource jobs, they demanded workers possess higher-level skills and additional education for the jobs that remained available (Friedman, 2016). The traumatic recession of 2008 exposed the crisis many workers faced. Into this churn, higher education experienced growing criticism over increasing costs, poorly prepared graduates, and limited job opportunities for many majors (Bok, 2008, Arum & Roksa, 2011). What has emerged since the recession and has continued during the recovery has been a call for a differently educated and prepared college graduates who can quickly adapt to innovation and rapid change in the workplace.

As the economy and workplace began to change in the early 1990s, David Guest introduced the term "T-shaped" to describe the technology savvy employee that would be needed in the immediate future. The T is a model meant to address emerging needs for talent in the workplace. Pryor and Bright (2011, p. 61) find such metaphors very helpful in "illuminating an aspect of reality" without capturing reality. Because of the complexity of the workplace, different observers may discern different patterns that either augment the T-model or propose a completely different one. The T-professional has become more widely embraced by corporate leaders, especially at IDEO, IBM (International Business Machines), Cisco, and at ISSIP (International Society of Service Innovation Professionals).

In our work, we cast the T-professional as an organizing principle, a vision or framework that embraces efforts to create a strong liberally educated college graduate/professional. The model brings together years of work by organizations such as the Collegiate Employment Research Institute (CERI) and the Association of American Colleges & Universities (AAC&U) that has transformed the conversation about the importance of a liberal education and fostered the implementation of learning outcomes. The T-model validates extensive research on the critical importance of deep disciplinary knowledge and extends that thinking to encompass the importance of knowledge and interaction within and across disciplinary domains. It highlights why the essential professional abilities delineated in the generally accepted goals for a liberal education are essential to student professional success.

The T-model adds two components that expand the conversation on the role of postsecondary education. First, it stresses the importance of developing a deeper knowledge of the systems, skills, and abilities needed to work within and across disciplines. Virtually no problem can be solved without crossing disciplinary boundaries, whether found in a single system or across diverse ones. Second, and the most important aspect, the T-model focuses on the ME (the individual).

ME

The Focus on the Individual

Develop confidence in your ability to contribute and take risks.

Understand that powerful learning often comes through failure.

Understand how your purpose fits into the world beyond your immediate environment.

Seek and strive to understand the perspective of others; that is, develop empathy.

The T-model frames the essential components of a rigorous postsecondary education. It highlights the knowledge, attitudes, and abilities that must lie at the core of a 21st century learning experience. It helps students develop the skills to survive and thrive in a complex and challenging world where adaptive innovation and boundary spanning are the keys to success.

Critically, it points us toward a fundamental truth about how institutions should function if they intend to foster adaptive innovation and boundary spanning, strive to address complex global problems, and educate the next generation of professionals. The T is the definition of student success! Although simple in theory, this model in practice requires significant cultural shifts as we determine what constitutes the learning experiences needed to develop the breadth of abilities characterized by the T. It requires top-down, bottom-up, and inter- and intra- institutional thinking along with fundamental philosophical and structural changes in the way we work and engage with others inside and outside our areas of expertise to solve problems.

We plan to produce a monograph in two parts. Included in Part I of the monograph are two sections. In section 1, we cover the various threads that shape the T-model. The evolution of the skills-gap literature rests on solid research of the need for breadth and depth. From the corporate perspective, the information is more anecdotal. It is from these anecdotal observations that the model emerged. The heart of this monograph is section 2 that centers attention on defining the different components of the T-model. We describe what each component represents from the perspective of higher education.

In Part II of the monograph our focus centers on the implications for undergraduate education (section 3) and the collaborative pipeline between higher education and organizations that seek T-professionals (section 4).

Section 1. Understanding the Threads that Shape the T

Different strands of thought, some well-grounded in research, provide enlightenment into the formation of the T-model. First, the emphases on deep knowledge combined with skills, competencies, and attitudes that broaden the individual's reach have resonated through workforce development discussions since the early 1990s. Second, today's workplace dynamics require individuals to take responsibility for their career advancement. This shift requires self-knowledge, awareness of highly connected systems, and the impetus to learn constantly. The

conclusion centers on the development of a new professional identity to sustain one's career aspirations.

This section highlights these individual threads. We could have included additional sources in some cases, but have chosen to provide fewer references for focus. The last segment of this section traces the origins of the T-model as it evolved in the business sector.

Skills and competencies that shape college graduates
Interest from industries and policymakers in shaping workforce development provides a critical context for the advancement and use of the T-model to develop T-professionals. These efforts have often framed the U.S. education system as both a source of labor market deficiencies and a promising site for solution strategies. Efforts to establish criteria, outcomes, and skill sets for postsecondary students have been decades in the making.

To avoid confusion we are using the terms skills and abilities interchangeably. The term competencies cast a wider net, embracing a collection of abilities, attitudes and behaviors. For this monograph we have employed the following definitions:

Skills are learned abilities that vary in complexity and require different degrees of training, experience, and practice. They demonstrate "what" an individual can do.

Competencies encompass a set of knowledge, attitudes, and abilities essential to becoming proficient at a set of skills. They tell us "how" an individual can do it.

Skills and competencies (1983-1991). A Nation at Risk — a report issued by President Ronald Reagan's National Commission on Excellence in Education — declared that chronic student underachievement threatened American economic competitiveness. "If only to keep and improve on the slim competitive edge we still retain in world markets," the introduction read, "we must dedicate ourselves to the reform of our educational system for the benefit of all... Learning is the indispensable investment required for success in the 'information age' we are entering" (NCEE, 1983). Critics of the report decried an ideological focus on "lazy students and unaccountable teachers" while leaving the impact of poverty and systemic inequality unexamined (Banones, 2015). Few of the report's recommendations were ever enacted.

Less than ten years later, the Department of Labor Secretary's Commission on Achieving Necessary Skills (SCANS, 1991) focused more explicitly on identifying competencies and foundational skills deemed necessary for graduates to succeed and contribute in the workplace (Table A).

SCANS was innovative for its time and remains relevant today. The authors identified the importance of systems thinking as a critical workplace competency. While the other skills and competencies named in the report surface in later treatments of this issue, systems thinking has gotten rather less attention, possibly because of a continuing focus on disciplinary knowledge over the knowledge, attitudes and abilities essential to working within and across system barriers and boundaries.

SCANS also included a glossary of educational terms for the foundational competencies it references. As educational reforms often stall when stakeholders fail to agree on defined terms, this committee's success in reaching consensus is noteworthy. This glossary of basic skills and competencies has been quite resilient. While SCANS served as the foundation for later studies, most failed to cover any significant new ground. Instead, their findings echoed the same industry concerns over the widening gap between a graduate's skill set and industry needs.

Accreditation (1990s). While the SCANS report provoked heated debate among K-12 educators, employers, and policymakers, it had little immediate impact on higher education. Pressure to address the postsecondary skills gap came instead through the efforts of an external accreditation group.

The Accreditation Board for Engineering and Technology (ABET) established global standards for academic programs of applied science, computing, engineering, and applied engineering. In the mid-1990s, ABET identified eleven outcomes (A to K), which insured that graduates from

ABET-accredited programs would have both demonstrated mastery of disciplinary knowledge and broadening experiences that provide the professional abilities to work across functional and organizational boundaries (Table B).

Table A. Workplace competencies and basic foundational skills, SCANS, 1991	
WORKPLACE COMPETENCIES	
Resources	Identifies, organizes, plans, and allocates (time, fiscal, material, human) Resources
Interpersonal skills	Effective team player, able to teach others, serves clients/ customers, exercises leadership, negotiates, works well with people from culturally diverse backgrounds
Information	Acquires and evaluates information, organizes and maintains files, interprets and communicates data, uses technology to process information
Systems	Knows how social, organizational, and technological systems work and operates effectively with them; monitoring and correcting performance; designing/improving systems
Technology	Selecting equipment and tools, applying technology to tasks, maintaining and troubleshooting technologies
BASIC FOUNDATIONAL SKILLS	
Basic skills	Listening, speaking, quantitative literacy, writing and reading
Thinking skills	Reasoning, seeing things in the mind's eye

Table B. Expected outcomes for graduates of accredited engineering programs, ABET, 1995
A: An ability to apply knowledge of mathematics, science, and engineering
B: An ability to design and conduct experiments, as well as to analyze and interpret data
C: An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
D: An ability to function on multidisciplinary teams
E: An ability to identify, formulate, and solve engineering problems
F: An understanding of professional and ethical responsibility
G: An ability to communicate effectively
H: The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
I: A recognition of the need for, and an ability to engage in, lifelong learning
J: A knowledge of contemporary issues
K: An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
NOTE: See also http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2017-2018/#general

A critical aspect of A to K is the careful wording of the outcomes. Most statements lead with able (revised to an ability to). The wording implies that, no matter how difficult, these outcomes must be measurable.

The ABET criteria captured the basic foundations skills from the SCANS report as they applied to engineering sciences, while also tapping into several of the broader workplace competencies like integrity, teamwork, and systems thinking. ABET's adoption and use of these criteria has had a significant impact on postsecondary engineering and computer science programs. Moreover, A to K has served as a useful model for other discipline-based accrediting bodies, many of which began developing similar outcome-based criteria. In the decades since SCANS employers have placed higher demands on the range of workplace competencies required of engineers; therefore ABET standards have recently been updated and consolidated.

Bases of Competence (1990s). Fred Evers (1996) at the University of Guelph (Ontario, Canada) led an initiative, hoping to better understand the employability of Canadian postsecondary graduates. Evers surveyed Canadian students and graduates at different times in the late 1980s. He found a growing gap between the skill sets students acquired at Canadian postsecondary institutions and those needed to thrive and contribute in the workplace. Building on the SCANS framework, Evers identified four skill sets – or "bases of competence" – that he found were most desired by Canadian employers when filling advanced-level positions (Table C). As with the SCANS report, Evers (1998) also created a glossary of terms, hoping to provide a common language that educators, employers, and policymakers could use in creating "educational experiences of practical and enduring value."

Table C. Bases of competence, Evers, 1996

Competence	Skill set
Managing Self: Constantly developing practices and internalizing routines for maximizing one's ability to deal with the uncertainty of an ever-changing environment	Learning; personal organization and time management; personal strengths and problem-solving/analytic
Communicating: Interacting effectively with a variety of individuals and groups to facilitate the gathering, integrating, and conveying of information in many forms (e.g., verbal, written)	Interpersonal; listening; oral communication; written communication
Managing People and Tasks: Accomplishing the tasks at hand by planning, organizing, coordinating, and controlling both resources and people	Coordinating; decision making; leadership/influence; managing conflict; planning and organizing
Mobilizing Innovation and Change: Conceptualizing, as well as setting in motion, ways of initiating and managing change that involve significant departures from the current mode	Ability to conceptualize; creativity/ innovation/change; risk-taking; visioning

Essentials for Success (1990s). Researchers at the Collegiate Employment Research Institute (CERI) at Michigan State University examined the critical skills and competencies that employers were seeking and how prepared seniors were perceived to be (Gardner, 1997). CERI found approximately 20 competencies were necessary for every graduate to show some level of ability as they entered the workforce (Gardner, 1997). Through a series of exercises with representatives from organizations that partner with MSU's Career Services office, the list was refined to 12 essential competencies that were defined and illustrated in a guide designed for students and advisors (Table D).

Table D. 12 essentials for success, CERI, 1997	
Working in a Diverse Environment	Learning from people who are different from you – and recognizing your commonalities – is an important part of your education and essential preparation for the world you will join.
Managing Time and Priorities	Managing how you spend your time, and on what, is essential in today's world. Learn how to sort priorities so you stay in control of your life.
Contributing to a Team	In the workplace each person's contribution is essential to success. Having the ability to work collaboratively with others is vital. This includes identifying individual strengths (yours and others) and harnessing them for the group building consensus, knowing when to lead and when to follow and appreciating group dynamics.
Navigating Across Boundaries	Life is filled with boundaries – good and bad. Discover how to avoid the boundaries that become barriers so you don't hamper the ability to collaborate with other people.
Acquiring Knowledge	Learning how to learn is just as important as the knowledge itself. No matter what your future olds, you'll continue to learn every day of your life.
Thinking Critically	Developing solid critical thinking skills means you'll be confident to handle autonomy, make sound decisions, and find the connection between opportunities you have to learn and how those opportunities will affect your future.
Performing with Integrity	It only takes one bad instance to destroy years of good faith and good relationships. It's important to develop a code of ethics and principles to guide your life.
Developing Professional Competencies	The end of college is the beginning of a new education. Build on what you already know and keep learning new skills – your job will challenge you to grow and develop in ways you haven't imagined
Communicating Effectively	Developing listening, interpreting, and speaking skills is just as important as reading and writing.
Solving Problems	You may only have thought about problem solving when you're faced with a crisis. Understand the process and mind-set of successful problem solving and you'll more easily handle the bigger challenges that come your way.
Balancing Work and Life	You've got a lot to accomplish in limited time. How do you get it all done and still stay sane? The key is maintaining balance among the different parts of your life.
Embracing Change	Just about every aspect of life is in a constant state of change. Sometimes it may seem that no sooner do you get caught up than you have to start all over again. No matter how you feel about change, you have to learn to deal with it.
NOTE: See also http://careernetwork.msu.edu/pdf/Competencies.pdf	

The Nine Work Strategies (1990s). During the 1990s, Robert Kelley and Janet Caplan (1993) investigated the performance of engineers and computer scientists at Bell Laboratories. They identified the qualities correlated with highly productive, innovative employees — a class of professional they dubbed star performers (Table E). They found that performing at a high level requires mastery of discipline (deep learning) and higher-level cognitive abilities (associated

with the higher levels in Bloom's taxonomy), coupled with the ability to demonstrate initiative. These core strategies were supported and enhanced by communication skills for persuading others, self-management, leadership, followership, teamwork, perspective, and — even before the social media revolution that delivered Facebook and LinkedIn – networks (or social capital).

Table E. Nine key work strategies of star performers, Kelley & Caplan, 1993	
Taking initiative	Accepting responsibility above and beyond your stated job, volunteering for additional activities, and promoting new ideas
Networking	Getting direct and immediate access to coworkers with technical expertise and sharing your own knowledge with those who need it
Self-management	Regulating your own work commitments, time, performance level, and career
Teamwork effectiveness	Assuming joint responsibility for work activities, coordinating efforts, and accomplishing shared goals with coworkers
Leadership	Formulating, starting, and building consensus on common goals and working to accomplish them
Followership	Helping the leader accomplish the organization's goals and thinking for yourself rather than relying solely on managerial direction
Perspective	Seeing your job in its larger context and taking on other viewpoints like those of the customer, manager, and work team
Show-and-tell	Presenting your ideas persuasively in written or oral form
Organizational savvy	Navigating the competing interests in an organization, be they individual or group, to promote cooperation, address conflicts, and get things done

2000 to present: back to the future? The loss of public funding for public higher education has corresponded with higher tuition levels across all types of institutions. Limited financial resources have presented challenges to sustain and expand career resources, especially for the increasing number of students from economically challenged households. Not surprisingly, rising costs have amplified student concerns about the value of money spent for a degree and the earning potential a degree confers. This has resulted in significant pressure on higher education to address stakeholder concerns about the gaps between college preparation and work readiness. These pressures have arisen during a period when members of the workforce are having to continually skill up to find or hold on to meaningful employment.

A number of studies released during this period have largely repeated the conclusions drawn by similar reports in the 1990s. The following studies are representative of those conducted over the past decade.

CERI. Researchers at CERI focused on the changing demands for skills and competencies throughout the workplace. In a series of studies researchers addressed the pace at which skills, abilities, work attitudes, and behaviors were changing and the importance recruiters placed on emerging skills during talent acquisition activities. Researchers compared job postings over a ten-year period, held focus groups with employers, and surveyed employers as part of MSU's national labor market study. The results showed that the starting positions for new graduates in 2007 more closely resembled Kelly and Caplan's star performers than starting positions in 2000. Today's requirements for internship and co-op positions, however, are the same as the requirements were for full-time starting positions five to seven years ago. Further evidence revealed that these competencies were becoming increasingly more important among employers throughout the early 2000s (Table F).

Table F. Competencies growing higher in importance among employers, CERI,
Build and sustain professional working relationships
Analyze, evaluate and interpret data
Engage in continuous learning
Communicate through justification and persuasion
Plan and manage a project
Create new knowledge
Gain a global awareness as relates to organization (also encompasses cultural
NOTE: See also ceri.msu.edu/wp-content/uploads/2010/01/skillsbrief1-2010.pdf

In a Boise State University case study, regional employers compared various skills and competencies as they determine success in a new college graduate's first job (Table G). This study used a best case-worst case technique that not only ranked skills and competencies but compared their relative importance. Instead of one or two competencies being more important than the rest, the competencies came clustered in bundles with both disciplinary and boundary-spanning competencies entwined.

Table G. Comparison of skills and competencies needed for a new college graduate, Boise State University, 2013	
Bundle 1	**Bundle 2**
Able to perform with integrity	Able to embrace change
Able to solve problems	Able to acquire knowledge
Able to manage time and priorities	*Able to manage and synthesize different sources of information*
Able to take the initiative	*Able to communicate effectively through writing*
Able to analyze, evaluate, and interpret information	Able to create original ideas and innovations (be innovative)
Able to contribute to a team	Able to plan and manage a project
Able to effectively communicate orally	Able to develop further professional
Able to build and sustain working professional relationships	
NOTE: Competencies in italic type are often attributed to deep disciplinary knowledge. The others build from all types of student engagement. See also https://career.boisestate.edu/wp-content/blogs.dir/1/files/2013/10/Employer-Feedback-On-Talent-Needs-Report-4-20131.pdf).	

In 2010 an employer's study of arts and sciences students compared the skills and abilities they excelled in to students from professional programs, such as engineering and business (Chan and Gardner, 2013). Arts and sciences students excelled in several essential work attitudes and behaviors; more than 60 percent of employers gave them high marks on strong work ethic, taking responsibility for their work and behavior, being cooperative and respectful, and functioning effectively in changing environments (Table H).

Table H. Comparison of skills and abilities for students from arts and science and professional programs, CERI, 2010	
Arts & Science Students: Stood Out	Professional Students: Stood Out
Communicating effectively (oral and written)	Demonstrating mastery of their academic discipline
Working in diverse environments	Analyzing, evaluating, and interpreting data and information
Creating original ideas and innovations	Planning and managing a project
Using persuasion and justification to advance Projects	Utilizing computer software and related technologies
Engaging in continuous learning	

American Association of Colleges & Universities. The American Association of Colleges and Universities (AAC&U) in partnership with Hart Research Associates closely examined the preparedness of college graduates and the perceptions of the value of liberal arts degrees. In this research, CEOs and other top executives responded for their organizations. (In comparison, CERI contacts recruiting managers and employers actively seeking talent from two- and four-year schools). AAC&U findings confirmed the necessity of graduates possessing deep disciplinary knowledge as well as mastery of competencies that cut across majors and experiences (Table I).

Table I. Competencies essential for success, AAC&U, 2007
Work in teams with individuals different from themselves
Communicate verbally and in writing
Analyze a problem and develop workable solutions
Think clearly about complex problems
Understand the global context in which their work is done
Apply knowledge and skills in new settings
Demonstrate quantitative literacy
Understand science and technology in real world settings
Be creative and innovative in problem solving
Demonstrate a sense of ethics

In a 2013 follow-up survey of executive leadership AAC&U and Hart Research Associates learned that employers faced more complex challenges in their assignments that required broader skills sets in addition to field specific knowledge. Employers stressed that broad skills trumped a candidate's undergraduate major in many cases. In addition, employers placed a high degree of importance on ethics, intercultural skills, and professional development.

In 2015, AAC&U and Hart Research Associates published selective findings of an online survey of employers and students. Employers wanted to see students more engaged in educational activities that involved gaining experience in active settings such as research, collaborative problem solving and projects, internships, and community involvement. Many employers believed colleges and universities could improve student preparedness for the workplace so that graduates possessed the knowledge, skills, and professional development needed for success.

These studies reaffirmed the skill and competency issues raised so long ago by the SCANS commission and echoed over the past two decades. What these studies did do was raise the

level of discourse among key higher education administrators at colleges and universities who could not very well ignore the issues being raised in their own professional association. Through these efforts, colleges and universities identified ways to improve pedagogical practices, expand experiential education, and give students opportunities to strengthen their competencies before entering the labor market. The telling value of these studies and the ensuing discourse will be whether colleges and universities build capacity for both depth and breadth, as defined by the T-model, in their educational experiences or fall back on old, easier to manage practices when the labor market improves.

Redefining the professional development mindset

Some observers of the changing workplace environment moved beyond identifying skill and competency gaps. They identified and described an entirely different set of principles (mindset) that workers would need to manage in order to advance their careers. Both those entering the workplace and those with experience will be required to have more knowledge about the industry where they seek employment or are employed, possess deeper self-knowledge, and be able to navigate multiple boundaries.

The career system of the 21st century is most likely to be boundaryless because of downsizing, restructuring, and subcontracting. Boundaryless careers unfold as people move among firms for projects, develop market niches rooted in competencies and strategies, and create opportunities based on prior performance and networks of professional contacts.

Anchoring their work in the film industry (populated largely by free agents), Jones and DeFillippi (1996) describe a "boundaryless network organization" in which fewer workers expect to spend an entire career within a handful of organizations. Using Kipling's (1902) couplet about the "six honest serving-men" who taught their master all he knew, Jones and DeFillippi identify six factors needed to survive in a boundaryless system in which "people move among firms for projects, develop market niches rooted in competencies, and create opportunities based on prior performance and networks of professional contacts" (Table J).

Entrepreneurship

The literature is extensive on entrepreneurship, but an article by Sarasvathy (2003) grabbed our attention because of how entrepreneurial expertise was characterized. In his essay Sarasvathy leverages key ideas from Herbert Simon's *Sciences of the Artificial*. The essay is based on conversations and emails exchanges between Simon and Sarasvathy about the empirical aspects of the author's dissertation. The commentary that interested us follows:

> Entrepreneurs begin with three categories of what I have called "means." They know who they are, what they know and whom they know — their own traits, tastes and abilities, the knowledge corridors they are in, and the social networks they are a part of. Starting with these means, the effectuator asks herself, "Given who I am, what I know, and whom I know, what can I do? What types of effects can I create?" Contrast this with causal reasoning that focuses on questions such as, "Given the particular goal I want to achieve, what ought I to do? Which particular path should I take?" Causal reasoning tends to begin with a universe of all possible alternatives and seeks to narrow the set of choices to the best, the fastest, the most economical, the most efficient etc. Effectual processes seek to expand the choice set from a narrow sliver of highly localized possibilities to increasingly complex and enduring opportunities fabricated in a contingent fashion over time (p. 208).
>
> Causal models are based on a predictive logic: To the extent we can predict the future, we can control it. Being able to predict the size, growth rate and potential trends of target segments, for example, allows the entrepreneurial firm to secure its own financial future (p. 208-209).
>
> Effectuation suggests a rather different logic for the choice process: To the extent we can control the future, we do not need to predict it. How does one control an unpredictable

future? The answer to this seemingly paradoxical question lies in the realization that a large part of the future actually is a product of human decision making (p, 209).

Table J. Competencies, challenges, strategies, and implications for boundaryless careers, Jones and DeFillippi, 1996

Competencies	Challenges	Strategies	Implications
Knowing WHAT: Industry opportunities, threats, and requirements	*Deal with uncertainty*: Remain "employed" Adapt to bouts of activity and inactivity Produce quality work	*Move career across and up*: Learn industry and enhance exposure Use projects and roles to build reputation	Inter-industry mobility constrained by professional networks
Knowing WHY: Meaning, motives, and values	*Manage career demands*: Keep passion without burning out Balance career and family	*Know your values and goals:* Commit to your craft Pursue your passion	Suited best for those whose primary value is the career
Knowing WHERE: Entering, training, and advancing	*Create a career path*: Train and enter the industry Remain in the industry Enhance future opportunities	*Gain credibility*: Get on-the-job experience Win industry competitions Maintain "face-time" in core	Be responsible for training, entry, and advancement Expect limited support from industry or
Knowing WHOM: Relationships based on social capital and attraction	*Master relationships*: Be strategic and genuine in relationships Become more than a resume of credits and credentials	*Manage social capital*: Offset instrumentality with friendships Use portfolios to showcase skills	Reassess whether to quit or continue relationships Know talent pool to assess skills
Knowing WHEN: Timing of roles, activities, and choices	*Develop career timing*: Don't be trapped in role or status Extend or exploit skills Move quickly for opportunities	*Reframe perceptions*: Break others' frame of reference Control pacing and choice of projects Make your own breaks	Synchronize projects and passion if possible Maintain passion in dry spells
Knowing HOW: Technical and collaborative skills	*Enhance collaboration*	*Expand communication skills*: Become cross-functional Develop & articulate vision Communicate with tangible products	Evade commodity status by creating idiosyncratic value in one's skills and roles

Traditional activities and strategies that students use to prepare for transition from college are grounded in causal thinking and models. We gather as much knowledge about job market trends, stability of certain occupations, and needs of employers to predict the future paths to take. This flips the thought process, challenging a student not to think about a specific job and plan but to have the understanding to control the future as it reveals itself. The key element borrowed from Sarasvathy is the means of "knowing who I am" or what becomes the critical ME component of the T discussed in the next section. To navigate the future as a T-professional, the individual must: know *WHO* I am; know *WHAT* I know; and know *WHO* I know.

Mental Demands

Robert Kegan (1995, p. 41) makes a strong argument for upgrading the educational experience when he contends that most of us, especially our youth, are "unable to put the world together at the required order of complexity, being in over his or her head, being inadequately understood" by adults. He challenges us to integrate the curriculum to achieve a "cross-categorical consciousness" as he related in the following analogy where we can substitute faculty for the lamp-maker (p. 50):

> If five lamps are lit in a large living room, how many sources of light are there? We might say that there are five sources of light. Perhaps the maker of each lamp, genuinely committed to bringing us into the light, will be partial to his own and bid us to come to the source. Or at best, some generous spirit of eclectic relativism may obtain, and the lamp-makers may concede that there is a benefit to our being exposed to each of the lamps, each separate source having little to do with the other except that, like food groups of a well-balanced diet, each has a partial contribution to make to a well-rounded, beneficial whole. But quite a different answer to the question of how many sources of light there are in the room is possible — namely, that there is only one source. All five lamps work because they are plugged into sockets drawing power from the home's electrical system. In this view, each lamp is neither a contender for the best source of light nor a mere part of the whole. Each lamp is powered by the whole, expressive of the whole. And if the lamp-maker's mission is not first of all to bring us to the light of his particular lamp but to bring us to the light of this single source, then he can delight equally in the way his particular lamp makes use of this source and in the way other lamps he would never think to create do also. His relationship to the other lamp-makers is neither rivalrous nor laissez-faire, but co-conspiratorial: the lamp-makers breathe together.

In his post-modern critique of learning systems Kegan contends that we leave traditional modes of inquiry, which are categorically based (concrete, inference, generalizations, hypothesis), and elevate learners at least to modes that deal with complex systems and eventually trans-complex systems (where more than one complex system interacts). To do this requires learners to cross boundaries, author their own learning (self-regulation, self-formation, autonomy), test paradoxes and contradictions, and explore relationships between different forms of learning. Kegan lays out this challenge because so very few are asked to experience this level of complexity in their learning; in fact, the advanced or complex levels of learning have been generally reserved for individuals pursuing advanced degrees (PhDs) and a highly select group of undergraduates. Yet in today's world all undergraduates need to be pushed into, led through, and supported throughout a collegiate experience that challenges them at higher levels of complexity. Kegan (1995, p. 303) states recommendations for what learners need to claim while in school to develop the skills, competencies, and abilities that will be expected of them in various roles in their adult lives:

- Exercise critical thinking
- Examine ourselves, our culture, and our milieu in order to understand how to separate what we feel from what we should feel, what we value from what we should value, and what we want from what we should want.
- Be a self-directed learner (take initiative; set our own goals and standards; use experts, institutions, and other resources to pursue these goals; take responsibility for our direction and productivity in learning)
- See ourselves as the co-creators of the culture (rather than only shaped by culture)
- Read actively (rather than only receptively) with our own purpose in mind.
- Write to ourselves and bring our faculty [sic] into our self-reflection (rather than write mainly to our faculty [sic] and for our faculty [sic].

- Take charge of the concepts and theories of a course or discipline, marshaling on behalf of our independently chosen topic its internal procedures for formulating and validating knowledge.

Kegan's work reinforces that portion of the T-model that is centered in the ME, self-authorship as an important component of self-evolution.

Constant Disruption from Technology

Technological change underlies much of the shifts in the economy that have manifested in skills and competencies gaps, the shifts in mindset toward employment, and the pursuit of more innovative strategies to engage in meaningful enterprises. We want to single out technological advances of all types, but especially cognitive systems (robotics and advanced software), because of the constant disruption they portend for workers at all levels throughout the workplace (Brynjolsson & McAfee, 2014; Ford, 2015; Mindell, 2015; Hill, 2015). It does not matter whether the advancement simply augments a human's ability to perform tasks more efficiently or replaces humans entirely. Successful engagement in the workplace demands diligence from individuals who are aware of potential shifts and respond adaptively and innovatively.

The perspectives on smart technologies runs from bright optimism about the future of mankind and machines as they become more singular (Kurzweil, 1995), allowing humans the ability to advance economically (Kelly and Hamm, 2013; Dormehl, 2016). On the other hand some observers are more pessimistic about the future as smart machines replace many workers and a very few individuals capture machine-driven profits (Brent, Gupta, and Sommer, 2013).

On the optimistic side are those who adhere to Schumpeter's process of creative destruction where economic processes and jobs are disrupted in some fashion to be replaced by new process and new jobs. Katze and Margo (2014) provide an historical view of the pervasiveness of technological change in the U.S. They show that technology hollows out jobs, which results in positions being created that require more skills and others that require lower skills. This hollowing out process is further illustrated by Friedman (2016) when he depicts technology as pulling jobs apart (high value elements that are skilled up and low value elements that are eliminated or handled by machines), pulled out (where cognitive software and robotics can do the entire job), and pulled down (jobs become obsolete). Friedman is less sanguine than others who espouse the equilibrium perspective (jobs destroyed, jobs created). Kurzweil, Brynjolsson, and McAfee (2014) have been initially confident that technology will not destroy jobs to such an extent that large numbers of workers will be unemployed. In fact Kelly and Hamm (2013), who argue the merits of cognitive computing as seen through the eyes of IBM's Watson, believe that cognitive computing will bring a jobs renaissance. The renaissance comes with a caveat in that workers will probably need more and higher level skills.

Others are more pessimistic. Pointing to the exponential growth of disruptive technologies (Gada, 2016; Johnson, 2015), these observers suggest that the adoption of cognitive systems is moving so quickly that more sectors, occupations, and businesses are being transformed. Technological disruptions are no longer rare events separated in space and time.

Disruptions are occurring across all job levels (service workers, professional, technical and managerial occupations, blue collar jobs). Nearly every occupation will likely be touched by a cognitive system (either augmented or replaced).

Unfortunately technological advancement produces winners and losers despite the eventual equilibrium in job destruction and job growth. Work that involves routine tasks, follows established rules and frameworks, and engages prescribed processes that can more likely be replaced by technology. However humans are still required to interpret and articulate results, anticipate new problems, and connect face-to-face. In these cases technology will augment or compliment human effort. Johnson-Eiola (2005) and Gada (2016) suggested several factors that have been integrated with our understanding of technological change that are worth keeping in mind as technology adoption proceeds throughout the workplace.

- Jobs will be lost and people will be unemployed for indeterminate periods depending on how fast new jobs are being created. Job losses can be sudden as seen in the dramatic effect new discovery software had on law and paralegal jobs or Uber had on unsuspecting taxi drivers.
- New jobs will be created, but the process will be messy. The timing of job creation does not coincide with the timing of job destruction. It may take years for the number of new jobs created to cancel out lost jobs. Job creation is not location specific. The industries, processes, and jobs created out of disequilibrium may not be in the same geographic area where the jobs were lost. Displaced workers may not be able to relocate to take advantage of emerging opportunities.
- Technological disruptions will change the mix of jobs available throughout the economy. Certain types of jobs or occupations disappear or are significantly reduced while other occupations grow in importance.
- New jobs will require different skills and competencies. Reich's (1991) symbolic analytic work replaces more routine work and requires workers to possess both technical and behavioral competencies. Levy and Murnane (2004) also stress the need for higher-order cognitive skills and higher-level communication ability, including justification, persuasion and negotiation.

Mindell (2015) makes a poignant comment that astutely captures the effect of technology on work: "Change the technology and you change the task, and you change the nature of the worker – in fact you change the entire population of people who can operate a system." The challenge for colleges and universities is the students' preparation so they can adapt to the constant disruption they will face in their professional life. This condition underlies the value of leveraging the T-model principles throughout undergraduate education.

The Evolution of the T-movement: A Business Perspective

The origin of the T-model is rooted in the business sector. Rich empirical studies on job performance, tenure, and job satisfaction have contributed to our understanding of factors that affect employee motivation and development. Research has singled out leadership, personality, communication competence, and job knowledge for examination. Researchers have bundled soft skills into their research. However, no empirical research exists that compares different types of professionals based on the degree to which they emulate depth and breadth as characterized by the T-model. The T-model has grown from anecdotal evidence, observation, and strong beliefs about the type of person best suited for the 21st century workplace.

Guest (1991) introduced the concept of the T-professional, commenting on the job situation in computing:

> This type of rounded personality is also sought in other branches of the same theory, which prizes individuals known as T-shaped People: These are a variation on Renaissance Man, equally comfortable with information systems, modern management techniques and the 12-tone scale.

At the same time other observers such as Palmer (1990) were introducing the term "hybrid" manager or professional. Palmer gamely wrote:

> The hunt for a new breed of computer manager is on. The British Computer Society, in a controversial report published last year, described the quarry as a "hybrid" manager who would combine business expertise with IT skills. The hybrid manager, it said, would be distinguished by his or her ability to relate to the 'broad picture' and to people, understanding their motivation and aspirations; he or she would also be energetic, intuitive, a good listener, and (cryptically) would have "an unusual set of interests."

Marco Iansiti (1993) at Harvard advanced the use of the term "T-shaped" in his work on complex systems:

> What follows is a typical profile for a successful integration team. In general, the members are the foundation of a system-focused approach to R & D. They possess a T-shaped combination of skills: they are not only experts in specific technical areas but also intimately acquainted with the potential systemic impact of their particular tasks. On the one hand, they have a deep knowledge of a discipline like ceramic materials engineering, represented by the vertical stroke of the T. On the other hand, these ceramic specialists also know how their discipline interacts with others, such as polymer processing — the T's horizontal top stroke.

Leonard-Barton (1995) expanded upon Iansiti's perspective by contributing the importance of organizational incentives and the drawbacks of the T-shape:

> In most organizations, T-shaped skills are not created as a deliberate policy but emerge because individuals have been willing to risk a somewhat marginal career. Most formal organizational incentives encourage I-shaped skills – the deep functional experience represented by the T's stem. As a result, the individual is driven ever deeper into his or her expertise, which the organization continually draws on and rewards.

Attention to the T-shaped person and the advancement of the concept appeared to have stalled at this point. It was not picked up again until a true T-evangelist appeared in Silicon Valley. Tim Brown, CEO of IDEO, an international design firm, not only recognized the importance of Ts, but also knew organizations could nurture Ts and reward them:

> Recruiting T-shaped People … We look for people who are inquisitive about the world that they're willing to try to do what you do. We call them "T-shaped people." They have a principal skill that describes the vertical leg of the T — they're mechanical engineers or industrial designers. But they are so emphatic that they can branch out into other skills, such as anthropology, and do them as well. They are able to explore insights from many different perspectives and recognize patterns of behavior that point to a universal human need.

Brown's Fast Company article quickly spread the T-model throughout the Silicon Valley innovation community and beyond. Chief innovation officers grasped onto the concept and shared it widely in their own writings. Estrin (2009) renamed T-shapes as adaptive innovators, a label often associated with the T.

Jim Spohrer (2005) capitalized on several decades of IBM, advocating for T-shaped professionals for his team's development of the disciplinary theory and knowledge known as service science management and engineering (SSME). Spohrer's efforts clarified various strands of service science thought, weaving a strong conceptual base for addressing the need for science and engineering education (and now all disciplines) to respond to industry's needs for research service innovation. SSME grounds itself in the belief that T-shaped people are the better collaborative innovators that industry needs to cultivate.

The Origins and Principles of Service Science Management and Engineering (SSME)

Chesbrough, H. & Spohrer, J. (2006) A research manifesto for service science. *Communications of ACM, 49*: 7, 35-40.

Donofrio, N., Sanchez, C., & Spohrer, J. (2010) Collaborative innovation and service systems: implications for institutions and disciplines. In *Holistic Engineering Education: Beyond Technology,* Grasso, D. (ed.) New York: Springer.

Maglio, P., Srinivasan, S., Kreulon, J. J., & Spohrer, J. (2006) Service systems, service scientists, SSME and innovation, *Communication of ACM, 49*: 7, 81-85

Maglio, P. P. & Spohrer, J. (2008) Fundamentals of service science. *Journal of the Academy of Marketing Science*. Springer.

Maglio, Paul P., Kieliszewski, C.A., & Spohrer, J. C. (2010) *Handbook of service science*. New York: Springer.

The Royal Society. (2009) Hidden wealth: the contribution of science in service sector innovation.

Spohrer, J. & Maglio, P. (2005) Emergence of service science: services sciences, management, engineering (SSME) as the next frontier in innovation. Presentation at IBM Almaden Research Center.

IfM (Institute for Manufacturing at the University of Cambridge) and IBM jointly published a white paper based on the proceedings from the Cambridge Service Science, Management and Engineering Symposium (July, 2007) and the consultation process (October-December 2007). Several paragraphs from this publication illuminate their commitment to the development of individuals with T-abilities:

> For education: Enable graduates from various disciplines to become T-shaped professionals or adaptive innovators; promote SSME education programs and qualifications; develop a modular template-based SSME curriculum in higher education and extend to other levels of education; explore new teaching methods for SSME education (p. 1).
>
> Service systems are dynamic configurations of people, technologies, organisations, and shared information that create and deliver value to customers, providers and other stakeholders (p. 1).
>
> New skills and knowledge required: The rising demand for service innovation has huge implications for skills and the knowledge base that underpins them. People are needed who can understand and marshal diverse, and increasingly global, resources to create value. Quite often, these resources are accessed using advanced ICT and new globe-spanning business models. The people with such skills are known as adaptive innovators: those who identify and realize a continuous stream of innovation in service systems (p. 4).

Advocates for T-shaped people often mention that the breadth of knowledge that transcends disciplines and experience enables faster adaptation to role changes and better communication skills for teamwork in multidisciplinary, multifunctional, or multicultural contexts. However, there is very little empirical evidence to substantiate these claims. Donofrio, et al. (2009) concede: "To date there is limited consensus on the definition of what a T-shaped person actually is and even less empirical evidence that supports the specific benefits claimed by advocates."

In a recent research article Hamdi, Silong, et al. (2016) found that teams utilizing T-model principles performed better in uncertain times but no differently when certainty is high. Their T-model is taken from an article by Lee and Choi (2003), but Lee and Choi did not describe

their survey assessment scale in terms of the T-model. This work did not advance the concept of the T-professional as it has been developed since 2003.

The void left by the lack of a clear definition of the T and empirical evidence regarding its applicability in the workplace has allowed others terms to pop up that fit the myriad perceptions of their originators, as described in these links to online articles. All are possibly valid extensions of the T-model. Yet, until we understand the T, even in its simplest form, the discussion will not advance but move in continual circles.

Online articles describing the T

From T to Pi: design skill expectations in change (Ville Tervo Lead UX/UI Designer, Trans.). (2015, January 08). Retrieved from http://futurice.com/blog/from-t-to-pi-design-skill-expectations-in-change

Which Letter-shaped will Future Employees and Leaders be ... (Esin Akay) (n.d.) Retrieved from https://www.linkedin.com%2fpulse%2fwhich-letter-shaped-future-employees-leaders-esin-akay&p=DevEx,5063.1

Building success in the future of work: T-shaped, Pi-shaped, and Comb-shaped skills. (R. Dawson, R.) (2013, March 21). Retrieved from https://rossdawson.com/blog/building-future-success-t-shaped-pi-shaped-and-comb-shaped-skills/

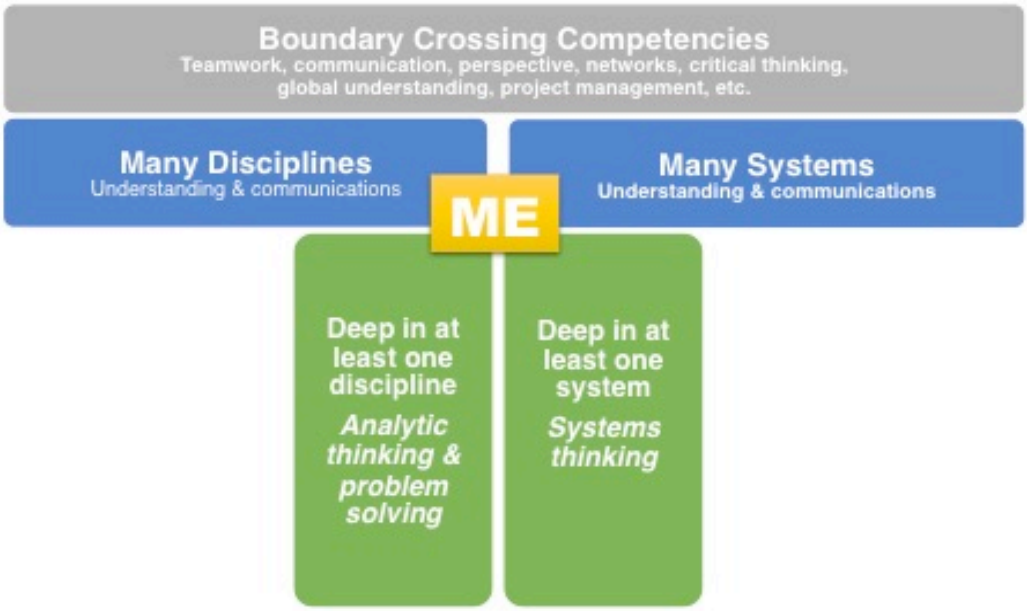
In the next section we discuss the components of the T-professional from the perspective of undergraduate education. We advance the rationale underlying each component's definition.

Section 2. Describing the T-professional.

Despite many years of deep discussion and anecdotal evidence, we have yet to agree on a commonly understood language describing the knowledge, attitudes, and abilities of the T-professional. A well-defined T language will ground subsequent conversations about the knowledge, attitudes, and abilities that should characterize post-secondary education and ongoing professional development. A well-understood T language offers the higher education community and the business community the chance to unify all the previous work and the work that will surely come.

In this section we describe the components of the T-model (Figure A). We do not intend to expand the scholarly work focused on creating consensus around such terms as disciplinary content knowledge, deep learning, or systems but rather to situate the T in these concepts. Nor do we intend to contribute to the significant body of scholarly work that has transformed our understanding of how students learn and continues to transform the learning experience by more deeply engaging students in the discovery of knowledge. Rather, the various components of the T situate the knowledge and practice of teaching and learning in a model reflecting the realities of a 21st century globally organized, technologically sophisticated, and rapidly changing world. The T-model illustrates how critical components of learning and a deep understanding of self (ME) interact and facilitate a working environment grounded in Tim Brown's definition of empathy — "one in which seemingly intractable challenges can be solved through the dynamic interplay of diverse teams contributing their knowledge and seeking out, deeply respecting, and striving to understand that of others."

Figure A. The T-professional or adaptive innovator, Spohrer (IBM), Gardner & Gross



Deep Disciplinary Knowledge

In some disciplines, particularly those accredited by professionally driven external agencies, considerable effort has focused on defining a disciplinary body of knowledge and by extension essential prerequisite knowledge. The goal is to frame professional responsibility and characterize both foundational knowledge and discipline specific content knowledge essential to professional practice and therefore key to undergraduate curriculum design (Eraut, 1994; Newman, et al., 1991; Blais, et al., 2015; Streveler, et al., 2006). Hill and Ball (2005) refer to this content as "common knowledge of content" or "knowledge held by all professionals in a particular knowledge domain inclusive of knowledge gained as a result of specialization within a knowledge domain." Further, the work of Bloom, et al. (1956) delineated progressively more complex levels of learning across three primary domains as the basis for establishing learning objectives and thus defining expectations for the depth of knowledge. Initially the work characterized learning in the cognitive domain; that is, knowing or remembering a set of facts or content and the range of intellectual abilities associated with using that knowledge. Later, the work expanded to recognize the affective aspects of learning (beliefs and values affecting how individuals interact within a knowledge domain) and psychomotor abilities (the motor skills or physical movements unique to mastering the discipline). Anderson, et al. (2001) expanded the characterization of knowledge from the original taxonomy to encompass the fact that knowledge was inclusive of factual, conceptual, procedural, and metacognitive abilities.

In the context of the T-model, deep disciplinary knowledge is defined as the domain of knowledge, inclusive of foundational knowledge, held by all professional in that discipline as well as that knowledge unique to a given specialization (sub-disciplines) within that domain and encompasses the psychomotor and affective abilities critical to a practitioner's success.

Deep Systems Knowledge

IBM contributed significantly to the T-model by including systems knowledge as a depth component. During the company's pursuit of solutions to key societal issues, they came to realize that solving a problem in isolation (without considering the solution's ramifications in other parts of the problem environment) did not necessarily solve the problem. It merely arose in another part of the system. IBM's response centered on their team members approaching problem solving from a systems perspective to determine that solutions did not manifest larger problems elsewhere. Awareness of systems knowledge is common in literature on problem-solving, but IBM stressed that their employees demonstrate ability in system understanding. This requirement echoes back to the need for system thinking in the SCAN report making system knowledge an essential T-principle.

The first step is to agree upon a simple definition of system, such as "a group of related parts that move or work together" or "a group of devices or artificial objects or an organization forming a network especially for distributing something or serving a common purpose" (Merriam-Webster dictionary, 2013). Meadows (2008) addresses a system‘s basic principle as "something more than a collection of its parts." When addressing complex problems, individuals or project teams have to understand the system in which the problem lies. This requires the use of systems thinking to understand the depth of "the complex behavior in order to better predict them and, ultimately, adjust their outcomes (Arnold and Wade, 2015, p. 670)."

What is systems thinking? Arnold and Wade (2015) survey the different definitions of system thinking since the terms introduction by Richmond (1987). They critiqued these definitions against a systems framework adapted from Meadows (2008) that consists of three components: elements (characteristics), interconnections, and a function or purpose (Arnold and Wade, 2015). All existing definitions failed the test against this framework. They then developed their own definition of system thinking.

In developing their definition, they recognized that "systems thinking could be viewed as a system." (p.670). "Systems thinking is, literally, a system of thinking about systems (p.670)."]The approach of Arnold and Wade nests nicely within the construct of the T-model. Arnold and Wade (2015) offer an objective definition of system thinking (in other words this definition has an expressed function or purpose):

> Systems thinking is a set of synergistic analytical skills used to improve the capability of identifying and understanding systems, predicting their behaviors, and devising modification to them in order to produce desired effects. These skills work together as a system (p. 675).

They also carefully define the terms used in their definition: (p. 675)

- Systems: Groups or combinations of interrelated, interdependent, or interacting elements forming collective entities.
- Synergistic: Interaction of elements in a way that when combined produce a total effect that is greater than the sum of the individual elements.
- Analytical skills: Skills that provide the ability to visualize, articulate, and solve both complex and uncomplicated problems and concepts and make decisions that are sensible and based on available information. Such skills include demonstration of ability to apply logical thinking to gathering and analyzing information, designing and testing solutions to problems and formulating plans.
- Identity: To recognize as being a particular thing.
- Understand: To be thoroughly familiar with, apprehend clearly the character, nature, or subtleties of.
- Predict: To foretell as a deducible consequence.

- Devise modifications: to contrive, plan, or elaborate changes or adjustments.

The authors addressed the elements and interconnections components, as specified by Meadows (2008). The elements are categorized as stocks or the resources available to a system, changes in resource or stock levels labeled as flows, and variables that Arnold and Wade (2015) describe as the "changeable parts of the system that affects resources and flows (p.677)." Stocks, flows, and variables behave linearly, but Arnold and Wade also suggest that non-linear behaviors also occur and should be recognized separately. Arnold and Wade depict systems thinking as a "series of continuous feedback loops" (p. 676) with no function ceasing at a final node. Rather, feedback continuously improves the connected elements. They lay out eight key elements that bind systems thinking (p. 676-677):

- Recognizing interconnections: this skill involves the ability to identify key connections between parts of a system.
- Identifying and understanding feedback: this ability requires identifying cause and effect feedback loops, caused by interconnections within the system, and understanding how they impact system behavior.
- Understanding system structure: requires an understanding of the system's structure (elements and interconnections) and how it facilitates system behavior.
- Differentiating types of stocks, flows and variables (linear): Awareness of or ability to differentiate and an understanding of the operational functions of the array of resources (supplies and services that are necessary to keep the system functioning) available in a system, how resources levels change (flow), and the variables influencing resources and flows.
- Identifying and understanding non-linear relationships: recognize that some resources and flows are behaving in a non-linear fashion.
- Understanding dynamic behavior: ability to recognize interconnections, the way they combine into feedback loops, and then influence resources, flows and variables, creating dynamic behavior within a system. (This ability requires system training to be able to differentiate the types of resources, flows, and variables, and to identify and understand non-linear relationships).
- Reducing complexity by modeling system conceptually: the ability to conceptually model different parts of a system and view a system in different ways. To perform this activity, one must extend beyond the scope of the defined system models and enter the realm of intuitive simplification through various methods, such as reduction, transformation, abstraction, and homogenization.
- Understanding system at different scales: the ability to recognize different scales of systems, and systems of systems.

Senge (2006, 1999) elucidates six important requirements for individuals engaged in systems thinking:

- A deep commitment to learning
- Being prepared to be wrong or alternatively open to challenging your own mental models
- Willingness to reshape those models
- Empathy which is defined as the ability to listen to others and come to understand their perspective and knowledge
- The ability to work as a team, effectively collaborating to address intra- and inter-system challenges

- Patience and perseverance

While Jim Spohrer at IBM was advancing service science theory, his team recognized that the problems they were solving tended to cluster in certain service systems. Explaining the T-model from IBM's perspective became much easier by putting a systems lens up to the service sectors that they were addressing. He operationalized the system concept around IBM's Smart Planet initiative because it allowed those unfamiliar with more academic presentations of systems to ground this dimension in something real, something they could recognize. Spohrer articulates the 13 system groups classified in three clusters that IBM believes each of us interacts with in our daily lives (Figure B).

Figure B. Thirteen Systems for a Smarter Planet: IBM's Smarter Systems

NOTES: 13 Systems © IBM
See also Jim Spohrer from IBM on Smart Service Systems with Cognitive Assistants www.youtube.com/watch?v=E7PVBGtEYyg and Service Science Progress & Directions - PowerPoint PPT Presentation www.powershow.com/view/3e034f-MzFlO/Service_Science_Progress_Directions_powerpoint_ppt_presentation).

In the context of the T-model, deep systems knowledge and its accompanying skill set of systems thinking can be defined as the understanding of intra- and inter-system complexity that embraces the physical, biological, economic, financial, social, organizational, and political processes, services, units, and events. These are comprised of resources and interconnected flows and variables, which produce feedback loops and involve human connections. These systems generate their own behavior patterns requiring open, innovative, and flexible thinking and self-learning that embraces other people's perspectives and persistence in the face of external and internal challenges that can impede finding solutions. Thus, deep system knowledge is enabled by an individual's boundary spanning abilities and concept of self (ME).

Breadth Boundary Spanning Abilities

Educational systems must create learning experiences with the express purpose of developing the knowledge, attitudes, and abilities critical for deep disciplinary knowledge and understanding and recognizing systems. The learning experiences must also intentionally cultivate those professional abilities essential for working within and across complex systems boundaries. Organizations, including corporate, educational, government, not-for-profit, and all other firms and establishments, must require inter- and intra-systems collaboration as a transparent component by creating initiatives or learning experiences that foster and subsequently reward individual development of the abilities encompassed by this breadth dimension of the T-model.

The knowledge, attitudes, and abilities critical to spanning the boundaries within and between disciplines and systems have become increasingly important for the T-model. Different boundaries are repeatedly encountered in solving system problems. A common boundary is between disciplines where an expert in one discipline encounters experts from other disciplines in working on a system problem. From his personal story, Gardner offers an example of a project focused on economic development in Thailand where he led a team consisting of a water specialist, salt-tolerant crop specialist, and labor utilization specialist, all focused on developing models for conversion of underutilized land into productive farms. To identify solutions, disciplinary experts had to create a shared language so that they could communicate effectively, understand alternative perspectives, and expand or enhance their understanding of disciplines different from their own. Thus, a group of specialists gained mutual understanding of their respective areas of expertise and recognized the value associated with different ways of knowing. Beyond functional boundaries, individuals will encounter situations where they will cross organizational, political, nation-state, cultural, and societal boundaries or what is referred to in the literature as boundary spanning.

These boundary-spanning abilities lie, in part, in the growing trend within postsecondary education to create interdisciplinary learning opportunities. Here the distinctions lay not only in differences in the body of knowledge but also critically the interchange of methods and languages between two or more disciplines. By developing the set of abilities that allows an individual to see new degrees of application, create new ways of knowing that may be grounded in more than one discipline, and recognize that in some cases, not all, new disciplines may arise at the intersections. These intersections generate valuable innovation and new understandings. We can offer examples such as entrepreneurship as a set of abilities that transcend disciplinary boundaries or unique pairings of more than one major or major and minors that achieve a similar objective. Interdisciplinary learning opportunities or courses only become, therefore, the means for "teaching" the cross-disciplinary, boundary-spanning skills.

However, in the context of the T-model, the ability to engage with other individuals trained in disparate disciplines goes beyond the transfer of knowledge potentially leading to a new disciplinary focus. While disciplinary language may be a barrier that needs to be addressed, especially if scientific, Strober (2011) believes the major problem is not accepting the "fundamental beliefs about how to ascertain knowledge." It becomes more about the way we think in interdisciplinary situations — our mindset, empathy, willingness to suspend judgment, curiosity, and perseverance until a solution is found— than about the creation of a new sub-discipline. How do the economist, the water engineer, the crop scientist, and the community development specialist work together? First they have to be open-minded and willing to explore a problem from various perspectives (something Strober says is a major stumbling block). Strober (2011, p. 4) believes they need patience, "suspending judgment until they obtain some mastery of strange ideas and methods."

Interdisciplinary environments (some intentional and some unintentional) emerge across most campuses in various forms. To advance T-principles institutions need to creatively develop and intentionally promote these interdisciplinary environments. The ensuing interdisciplinary conversations will allow students to suspend their models, personal judgments, and biases and work toward understanding alternative perspectives. The students' experience will impart

confidence for them to traverse disciplinary boundaries and recognize that boundary-spanning competencies when applied across disciplines and systems often lead to more comprehensive solutions to complex problems.

T-professionals must be able to work across, within, and through multiple contexts. Tushman and Scanlan (1981, p. 84) proposed that boundary spanners "are strongly linked externally and internally, so that they can both gather and transfer information from outside their sub-unit." Some of these boundary-spanning abilities can be gained through coherent learning experiences within, and likely most importantly, through engagement in contexts outside the college classrooms or the traditional learning environment. As Griffiths and Guile (2003, p. 69) claimed: "Learners have to develop the capability to mediate between different forms of expertise and the demands of different contexts, rather than simply bringing their accumulated vertical knowledge and skill to bear on a new situation."

Miller (2008, p.628) identifies these selected characteristics of boundary spanners:

- Work freely and flexibly in multiple contexts
- Understand the complexities of collaboration
- Use a wide array of individual and organizational contacts
- Engender trust and respect from diverse constituents
- Work to unite and mobilize disparate groups
- Collect and disseminate information

When Harvard Medical School reframed their medical curriculum, boundary-spanning expertise became a critical framing component. What they learned was that boundary spanning meant more than abilities to engage in teams, undertake project management, or collaborate with culturally diverse associates. It meant being able to embrace a range of attributes that transcended competencies, as characterized by Jo Solet (Wilson, 2009, p. 10):

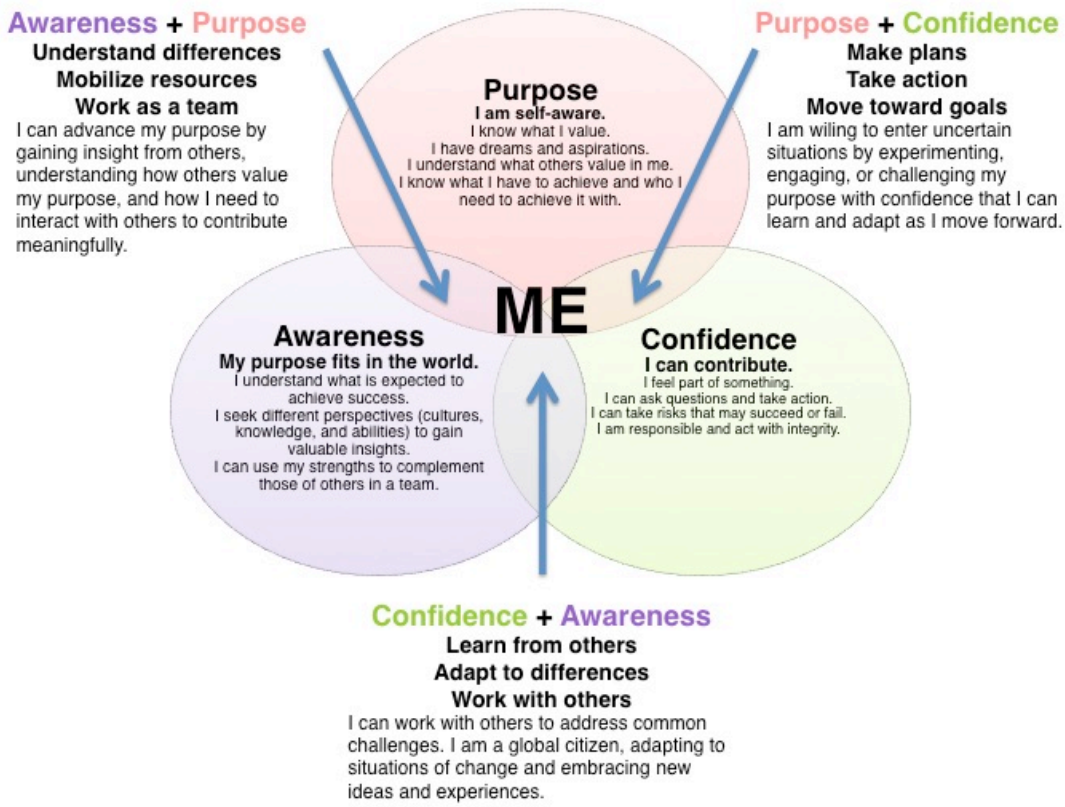
- Alertness: detects important opportunities and notices unexpected consequences
- Active: provides bridge to and for others
- Risk-taker: sees mistakes as necessary trials toward success
- Secure learner: enjoys excitement of steep learning curve
- Flexible, fluid identity: can step into and fit into worlds of others
- Emphatic: helps others feel known, safe, and accepted
- Committed: persists in holding a goal or sense of mission
- Curious: driven to understand and find solutions
- Tolerant of ambiguity: avoids premature closure; allows time for experimenting, fast prototypes
- Good communicator: translates and integrates; develops shared knowledge
- Humble: doesn't take self or role too seriously, can use humor

Boundary spanning embraces building relationships and connections across borders, groups, and interests. To span boundaries successfully an individual relies on a broad set of abilities and behavioral attributes as highlighted in the examples. ***A boundary-spanning individual within the T-model possesses the "ability to develop partnerships and collaboration by building sustainable relationships, managing through influences and negotiation, and seeking to understand motives, roles, and responsibilities"*** (Williams, 2002).

ME – Self Actualization

The most critical component of the T is the ME, which reflects the individual's knowledge of self. It points to the "know thyself" contributions of Herbert Simon (Sarasvathy, 2003), self-regulation (author's own learning) of Kegan (1995), the attitudes and behaviors of Wilson (2009) and Jones (n.d.) who emphasize knowing one's inner self to make the most of changing situations (https://www.trainingabc.com/everyday-creativity/). Gardner, with assistance from Estry and Gross, embedded the ME dimension into the T-model as the core that holds all the other components together. The ME is critical to developing the ability to function as a T-professional and is in part the individual's ability to understand core values and motivations. Gardner, Gross, and Estry characterized the ME as three interlocking dimensions consisting of purpose, confidence, and awareness (Figure C).

Figure C. The ME Self-actualization, Gardner, Gross & Estry



Building Blocks of Purpose, Confidence, and Awareness. The T-model blends well with key theoretical constructs of student and career development. We highlight several here to demonstrate the connections between the facets of the ME in the T-model and the body of literature focused on student development and academic success.

Research shows students who have a clearer sense of purpose have an increased likelihood of academic success. Tinto (1993) established that student goals, both short- and long-term, influenced decisions. Hull-Blanks, et al. (2005) found that career goals and retention were related. Caliste (1984) found that career goals influenced motivation and relevance. Altmaier (1983) found that uncertainty about career goals has been associated with poor academic performance; whereas Emerick (1992) found that grades improved when students had better developed career goals. Students who either affirmed, reaffirmed, or discovered their PURPOSE will more likely be retained, perform better academically, and be more motivated to engage.

William Damon (2009) emphasizes the importance of purpose in all aspects of a young person's life. He distinguishes purpose from a goal by shaping purpose around (1) a long-term commitment that is personally meaningful and (2) a commitment that is socially beneficial, extending beyond oneself. ***His definition of purpose fits well within the T-model: "a stable and generalized intention to accomplish something that is at the same time meaningful to the self and consequential for the world beyond the self."*** (p.33)

Students who actively embrace awareness of themselves and the world around them are able to navigate their purpose to a higher level. Kegan (1994) observed that the relationship between self and others, self and the environment, and self and the world was the most significant aspect of "becoming." He calls this becoming "meaning-constitutive evolutionary activity" or the restless creative motion of life. Parks (2000) noted: "Individual persons are not their stages of development but are a motion, within which what has been called stages of development are merely moments of dynamic stability – temporary balance." Kegan has removed the stages and speaks to the making of meaning (self-authorship), which evolves over time and increases in complexity. Baxter Magolda's (1992, 2004) work into self-authorship builds upon Kegan's groundwork, linking self-authorship principles by focusing on AWARENESS to gain self-knowledge and begin crafting one's own story.

In the T-model awareness is defined as knowledge and understanding of others (empathy) and knowledge of self. One's capabilities – strengths, weaknesses, ways of knowing and understanding – ideally include recognizing the importance of others and the value that that diversity brings to the resolution of challenges and problems.

Students who have confidence are able to engage more fully to develop skills toward achieving their purpose. Goals are linked to self-efficacy (confidence) by Schunk (1990) and to vocational interests (Lent, et.al, 1988). Hackett, et al. (1989) noted that higher self-esteem (confidence) predicted career salience. Nauta, Eperson and Kahn (1998) and Schaefers, et al.'s (1997) studies on women reported that confidence linked to career aspirations. Bandura (1982, 1997, 1980) posits four factors that affect the development of self-efficacy: experience (learning by doing); modeling (vicarious experience in learning from others); social persuasion; and physiological factors (for example, stress). Students are more likely to develop self-efficacy through active experience, access to role models, and reinforcing community messages. An equally important dimension of confidence with regards to the T is the willingness to experiment, fail, and learn from failure. Organizations use failure to their advantage as it often opens opportunities and suggests that institutions have to create learning environments in which students can fail without serious repercussions (Cigman, 2001; Cannon and Edmondson, 2005). Self-reflection is critical and aids an individual in shaping each dimension of the ME. The dynamic aspects of ME development involve interactions with others, introduces new learning contexts, and challenges one's thought processes; these occur in the areas where the circles overlap.

In the T-model confidence includes being a risk taker and, in Wilson's words, "seeing mistakes as necessary trials toward success" T-professionals are comfortable and confident in their knowledge and at the same time seek and embrace the knowledge of others or are able to suspend their own mental models in order to consider alternatives (Senge), being, again in Wilson's words, "secure learner[s], tolerant of ambiquity."

Confidence + Awareness. When confidence and awareness connect, individuals accept others as important agents in their development. They realize and are open to learning from others; can adapt to differences that include new and challenging learning contexts (workplace, laboratory, everywhere learning takes place); ways of thinking and information generation from other disciplines; and different cultural backgrounds and mindsets. Critical to the transition to the workplace is being able to effectively work with others. Positive outcomes in this context would be: I can work with others to accomplish common challenges; I am a global citizen, adapting to situations of change and embracing new ideas and experiences.

Awareness + Purpose. In these two dimensions, the individual needs to understand the differences they encounter (not simply adapt) and recognize the differences as potential resources. One's ability to mobilize resources depends on recognizing that a single individual does not have to possess all the required resources. Other individuals, teams, and organizations can be tapped to collaboratively share and utilize resources. In this space, an individual's ability to work within a team to advance a shared goal or task is essential. Suggested outcomes would include: I can advance my purpose by gaining insights from others; I can understand how others value my purpose; I know how I need to interact with others to contribute meaningfully.

Confidence + Purpose. When individuals possess confidence in experimenting and possibly failing, in asking questions and seeking resources, and taking responsibility for their own actions, they are poised to take action. Action best plays out if the individual can articulate values and possesses defined interests shaping an overarching purpose. The stage is set for establishing a plan, setting short-term and long-term goals, and then acting upon these goals. It is all about forward movement. Individual outcomes would encompass: I am willing to enter uncertain situations by experimenting, engaging, or challenging my purpose; I can learn and adapt as I move forward.

The ME situates the knowledge, attitudes, and abilities characterized in each of the other components of the T (Deep Disciplinary Knowledge, Deep Systems Knowledge, and Boundary Spanning Abilities) within the enacting individual. It requires a significant degree of continuing exploration into defining and refining purpose, understanding what you value and what others value in you. It requires the confidence to take risks and eschew the familiar in order to discover and expand your purpose. (We often learn the most from failure.) Importantly, consistent with a key component of systems thinking, the ME means that seeking out perspectives different than one's own helps you gain critical insights.

Summary of the T-model: principles and definitions

At the outset we cast the T-professional as an organizing principle, a vision or framework that embraces efforts to create a strong liberally educated college graduate/professional. The strength of the T-model for this purpose rests on three key principles:

- Being innovative: open to creative ways to stimulate learning through curriculum design, technology and space utilization
- Being intentional: embrace T-learning openly across all disciplines and support units as piecemeal, ad hoc approaches seldom work
- Being integrative: practice reflection, storytelling and other devices to assist students integration across all their experiences. The T-model is not composed of separate, unconnected events. Rather the T is a system and requires practices to insure students can understand how they can develop their skills and become T-professionals.

Finally, our definitions or descriptions of the T-components are repeated here to highlight them without the noise of the surrounding discussion.

Deep disciplinary knowledge is the domain of knowledge, inclusive of foundational knowledge, held by all professional in that domain as well as that knowledge unique to a given specialization (sub-disciplines) within that domain and encompasses the psychomotor and affective abilities critical to a practitioner's success.

Deep systems knowledge and the accompanying skill set of systems thinking is the understanding of intra- and inter-system complexity that embraces the physical, biological, economic, financial, social, organizational, and political processes, services, units, and events comprised of interconnected resources, flows and variables, that produce feedback loops, and involve human connections. These systems generate their own behavior patterns and require open, innovative, and flexible thinking and self-learning that embraces others' perspectives. The systems also require persistence in the face of external and internal challenges that can impede finding solutions.

A boundary-spanning individual within the T-model possesses the "ability to develop partnerships and collaboration by building sustainable relationships, managing through influences and negotiation, and seeking to understand motives, roles, and responsibilities. (Williams, 2002)"

Purpose is "a stable and generalized intention to accomplish something that is at the same time meaningful to the self and consequential for the world beyond the self (Damon, 2009)."

Awareness is knowledge and understanding of others (empathy) and knowledge of self, one's capabilities – strengthens, weaknesses, ways of knowing and understanding – and recognition of the importance of others and the value that that diversity brings to the resolution of challenges/problems.

Confidence includes taking risks and, in Wilson's words, "seeing mistakes as necessary trials toward success," being comfortable and confident in one's knowledge, and seeking and embracing others' knowledge, or suspending one's own mental models in order to consider alternatives (Senge), thereby being, again in Wilson's words, "a secure learner (that is) tolerant of ambiquity."

Establishing a Trading Zone for Conversations on the T

To educate and nurture the T-professional, multiple experts will have to contribute knowledge and resources. Since the T-model is a normative concept with no established common language or processes, experts view the T through differing, clashing lenses that can obfuscate discussions and deter opportunities to move forward. To establish a common language requires not only time, but also a safe place to discuss ideas and build programs. The "trading zone" offers an environment conducive to advancing the T.

When various stakeholders come together, bringing different values, perspectives and practices, Gorman (2011) suggested they need a trading zone to exchange ideas, knowledge and negotiate compromises. Galison (1997) developed and Collins, et al. (2007) clarified the concept of the trading zone to overcome problems that arise when experts assemble, their conceptual frameworks clash, and language gaps thwart their attempts to directly compare theories or other empirical evidence. Galison described the trading zone in these terms:

> Two groups can agree on rules of exchange even if they ascribe utterly different significance to the objects being exchanged; they may even disagree on the meaning of the exchange process itself. Nonetheless. The trading partners can hammer out a local coordination, despite vast global differences. In an even more sophisticated way, cultures in interaction frequently establish contact languages, systems of discourse that can vary from the most function-specific jargons, through semispecific pidgins, to full-fledged creoles rich enough to support activities as complex as poetry and metalinguistic reflection.

Gorman's work (2002, 2011) to advance the use of trading zones captures several key characteristics:

- Common language is necessary to overcome barriers to collaboration (citing Galison, 1997). Gorman contends it may not start as a fully functional shared language but evolves incrementally from jargon to pidgin to a shared creole (Gorman, 2011). This kind of hybrid language will integrate the multiple fields necessary to drive interdisciplinary T-model education and training.
- Intersectional expertise, which Gorman and Collins, et al. (2007) associate with T-model principles, is necessary to understand the various perspectives and disciplinary experts in the trading zone and facilitate serious discussion. According to Gorman, at least one person has to be able to "walk the talk" of another discipline. Someone who understands enough about the assumptions and practices of another discipline to make intelligent suggestions about research strategy without being able to "walk the walk'" of actually performing said research.

- Participants in the trading zone must agree upon a normative scenario which "guards against change for its own sake." Gorman emphasizes that the normative scenario should convey a sense of urgency or be critically important to overcome the "objections that arise when participants look at change from the perspective of the descriptive scenario."
- Members have a willingness to do empirical research on how to create and manage the trading zone.
- The major challenges of assembling a wide variety of participants to discuss a subject that extends beyond a single discipline, sector, business, institutional culture, or student group are the conflicting and competing cultural, values, norms, and biases. Operating effectively in the trading zone means managing the discussion so that it includes these differences.

Preview of Monograph Part II

Part II of this monograph contains two sections:

- Section 3. Transforming the undergraduate educational experience
- Section 4. Building the infrastructure (pipeline) that transports emerging T's in colleges and universities into the workplace.

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