



Constraints and Pitfalls Encountered in Crossing the Threshold to Transdisciplinary Problem-Based Learning

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September 2017

INTRODUCTION

This report focuses on the constraints and pitfalls teachers face when transitioning from traditional learning strategies to transdisciplinary problem-based learning (TPBL). In educational theory these thresholds are associated with culture shifts and new demands on educational strategies that meet changing societal needs. Thresholds have two sides, the approach to the paradigm shift and time immediately following when confidence in the processes is still forming. Both the approach to change and the time following are charged with liminal constraints that must be navigated and pitfalls that test confidence. Partnering with administrators, teachers, students and community to navigate constraints and build confidence is the focus of the PAST Foundation. PAST uses an array of methodologies to better understand perceptions and inform actionable pathways so that the transitions are successful.

CULTURAL NORMS AND ASSOCIATED THRESHOLD CONCEPTS

Cultural Anthropology established in the early 19th century both the universals and particulars of culture (Barnard 2000). The universals are broad common features that create systematic responses to basic needs while the particulars are distinctive attributes of cultural response to that basic need. For

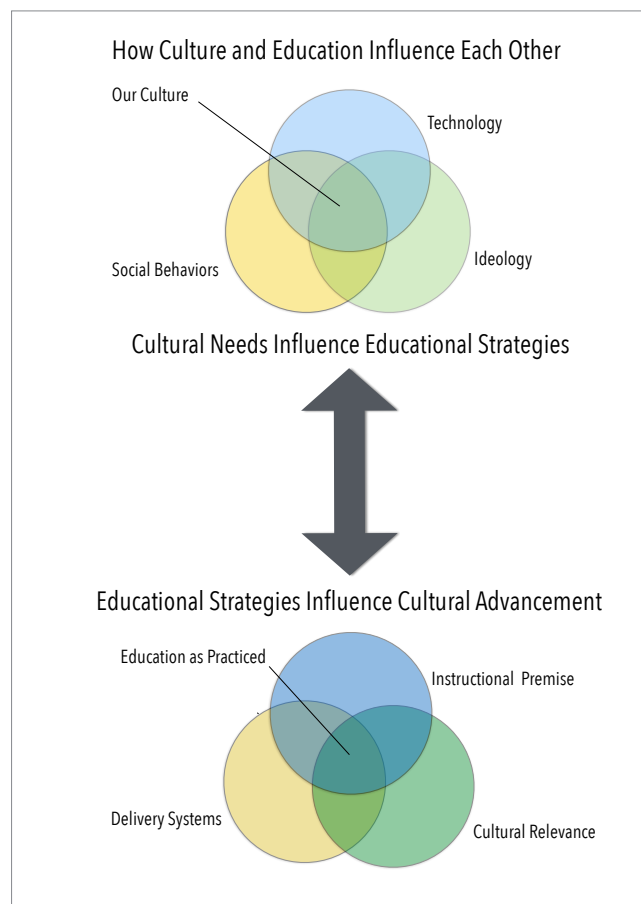


Figure 1. The cultural universal of educating each generation



example, every culture has a system of passing knowledge to the next generation. With changing societal needs, individual systems respond by transitioning to meet the new set of needs. The period of transition introduces new concepts and approaches, which represent a threshold or series of thresholds. Those within the society responsible for maintaining the systems are charged with embracing and building new habits and norms. Systems help maintain the norms that drive sustainability. Each cultural system may look and feel distinctive but they all address the same needs.

So too, every organized educational system that guides learning has instructional and delivery strategies grounded in the surrounding community, creating a cultural strategy. Together these universal strategies enable cultures to communicate knowledge and norms from one generation to the next (Figure 1).

Formalized educational strategies help define the WHY and guide the HOW in academics establishing norms of teaching and learning. The particular needs of each community fluoresce as WHAT these strategies look like when applied, creating the unique attributes of each school. No two schools are identical even though they may employ the same instructional and delivery strategies. The interaction of administration, teachers, children, and community give each school a unique cultural identity. Thus, the societal choices of instructional strategy, the delivery strategy and the cultural strategy are the threshold concepts. When the interaction of the chosen strategies or threshold concepts come into equilibrium the habits and norms are fully established. However, transitioning from one set of educational strategies to another creates tension resulting in constraints and pitfalls to adoption. The constraints leading up to the transition and the pitfalls encountered in the early phases of adoption are all part of the intermediate phase or *liminal tunnel* associated with the shift (Figure 2).

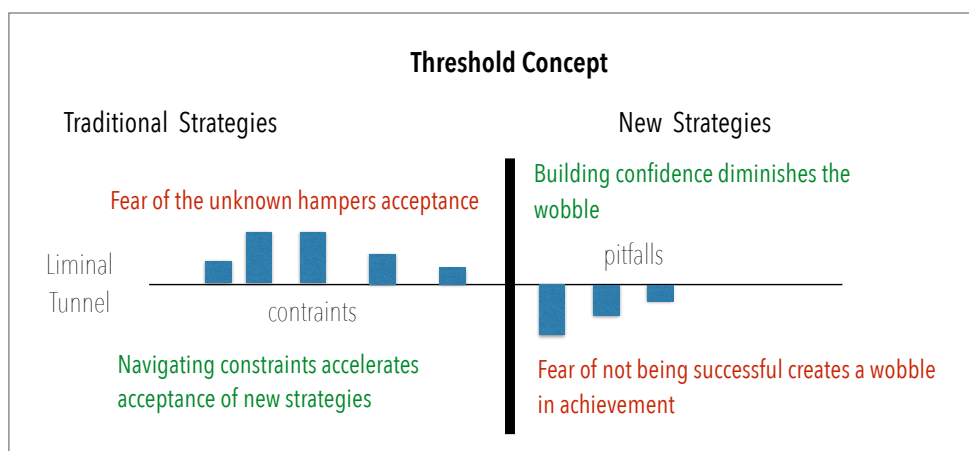


Figure 2. Constraints and pitfalls associated with transition.

It can be argued that the U.S. is in the intermediate period of transition of educational strategies that answer the societal needs of the 21st century. To understand the transitioning constraints and pitfalls



associated with problem-based learning it is essential to understand the predominant educational instructional, cultural, and delivery strategies in the U.S. and the constraints associated with the shift to problem/project-based or STEM instruction and delivery.

19TH AND 20TH CENTURY EDUCATIONAL STRATEGIES IN U.S.

In the U.S. the textbook/lecture instructional and delivery strategies have dominated educational models since the early 1900's. These educational strategies supported the industrial needs that emerged with the industrial revolution and rise of manufacturing. In short, these strategies quickly and efficiently created an educated workforce for "assembly line" manufacturing. However, textbook/lecture strategies were never the only strategies, a number of different models developed with the rise of public education including Montessori, Waldorf, military, and numerous religious models (Katz 1976). However, these have until recently been considered alternative models.

By the 1980s industry and government organizations were beginning to voice concerns over the decline of problem-solving, critical thinking, and collaborative skills lacking in young graduates coming out of the textbook/lecture educational model. In response to publications like *A Nation at Risk*, a national movement for educational standards arose and by 2001 standards for core content subjects of mathematics, English/language arts, science, and social studies were adopted across the U.S (National Commission On Excellence in Education 1983). The prevailing contention was that codifying the essential concepts and aligning them to textbooks and lectures would address the growing lack of essential reasoning skills evidenced in those entering the workforce. Textbooks became aligned to standards in an effort to alleviate the pressure on teachers and assure that what they taught was concept or standards driven. Emphasis was placed on abstract concepts rather than applied learning and on the verbal modality of learning rather than visual, aural, logic, or kinesthetic. Courses such as "shop," "home economics," and even science lab classes slowly began to disappear in K12 educational models.

Industry, post secondary institutions and many educators began actively lobbying for alternative models that would fulfill the current needs of workforce development and build critical problem-solving, collaboration, communication skills, as well as grit (Band 2013; Turbot 2015). Outspoken educators such as Sir Ken Robinson and Sugata Mitra continue to lobby for a paradigm shift in educational strategies that meet the needs of the 21st century, pointing out that today's literacy needs are different from the needed literacies of the 19th and 20th centuries. Mitra was quick to point out that the predominant strategies are not broken but rather misaligned with contemporary cultural needs (Robinson 2014; Mitra 2013). As the new century dawned with multiple shifts in technology, ideologies, and social behaviors, a generalized shift coalesced in education drawing on problem-solving strategies that reintegrated disciplines, and refocused on definable societal and cultural needs. Introduced as "design thinking" and eventually referred to as "STEM" (an acronym for Science, Technology, Engineering and Math), these



designations signaled the return to applied learning strategies grounded in real world problems that resonate with advancements in technology and the sciences (Wiggins 2005). Shifting to a problem/project model also signaled a transition in the way teachers need to be trained and the way students learn. This shift highlights the liminal constraints faced in moving toward employing new strategies and the pitfalls associated with growing confidence in delivery.

NOTED CONSTRAINTS AND PITFALLS IN THE U.S. EDUCATIONAL SHIFT

There are a number of fears that teachers identify in the application of new instructional and delivery strategies. A recent survey of a rural school district's leadership team identified; 1) less than perfect project management and project outcomes in first attempts; 2) unfamiliar classroom layout; 3) classroom noise levels of student engagement; 4) not having all the answers; and 5) student academic performance on standardized tests (Deaner and Hunter 2017). Teacher preparation often lacks guidance essential for project management and student group facilitation with multiple, concurrent aspects in play during the course of classroom activities. Residual mythologies that "only in a quiet classroom can learning take place," are up-ended with implementation of problem-based learning environments. The classroom within a problem/project based learning environment looks different in regards to teacher facilitation, student participation, and physical space. The learning environment is active and often "messy" or seemingly chaotic, forming a stark difference to the traditional classroom where students are obediently sitting in seats. Over time, teachers gain confidence, no longer viewing these fears as pitfalls.

When a specific model of educational instructional, delivery, and cultural strategies dominates the industry, the constraints associated with mastering the strategies are minimized. After all, for a teacher who has gone to school since he or she was five years old, the textbook/lecture model is a very familiar comfort zone. Surveys of students reveal that by the third grade, textbook/lecture strategies have become habit and expectation. By the time a young teacher finishes college they have 16 years of experience with the textbook/lecture model. Thus the familiar instruction, the delivery, and relationship to community are well established. Even if these strategies no longer resonate with the needs of the culture, the familiarity makes it difficult to eschew the habits associated with the model. New models such as problem-based learning with its project-based delivery and tight ties to community represent the unknown. Change is fraught with fear of the unknown and constraining perceptions that complicate smooth transition across threshold concepts that can drive resistance. Pitfalls in mastering a new delivery system creates a "wobble" in full transition to confident facilitation.

When there is a profound shift in strategies, liminal constraints on both sides of the threshold, delay change. Currently the dominant textbook/lecture educational strategies in the U.S. are experiencing sustained pressure to change. At first the pressure focused on more aggressively benchmarking learning



through standardized assessments as a means to increase academic success. The *No Child Left Behind* Act sought to add rigor to instruction without changing the strategies (U.S. Congress 2001). From this approach of amending the instructional, cultural, and delivery strategies rather than shifting to alternative strategies, a number of unintentional consequences arose that compounded the liminal constraints associated with each of the threshold concepts.

First, increased emphasis on rote memorization creates a “right/wrong” environment that gradually eliminates experimentation and exploration of multiple solutions that exist side-by-side. Second, the art of negotiation and critical thinking declines. Projects become fun exercises rather than a means to solving a problem. Third, the “right/wrong” environment fosters the notion that the teacher is the “Sage on the Stage” and keeper of all correct answers. In these instances, willingness to facilitate learning declines if the teacher does not know the outcome. Problem solving becomes a series of “right/wrong” steps handed to the student with a single conclusion at the end. Last, the “one-size-fits-all” limitations of a textbook divorces learning from the immediacy of community needs. Content in the textbook may have little resonance with the foundational knowledge of a child. Textbooks propagate the specialization of content, creating silos of learning that disassociate context from concept. For example, an algorithm becomes an abstract equation bereft of the reason and practical value for its development and application.

These unintentional consequences of textbook/lecture strategies fuel many of the fears associated with shifting to problem/project-based strategies that are grounded in community needs. Ameliorating fears empowers educators to successfully navigate the liminal constraints associated with the transition of strategies accelerating the paradigm shift across threshold concepts. Bolstering confidence of educators in mastering new strategies decreases academic “wobble” for both teachers and students. Once the shift is complete, the strategies become habit and norms are developed, helping bring others across the threshold concept.

Cultural needs drive change and sometimes unintentional consequences of one paradigm amplifies the pressure to change. In education the prolonged use of textbook/lecture strategies and its unintentional consequences have accelerated the traction of STEM learning strategies. Most new schools in the U.S. adopt one or more of the strategies associated with STEM learning. With time, STEM has come to mean more than simply the sum of the acronym, yet many still want to adjust the title to accommodate specific disciplines reflecting a continued hold on silo’d learning. In the U.S. we find STEAM, STREAM, STEMH, STEM² and STEM³, and even SWEATER demonstrating a major constraint: fear of exclusion (Smith and Corbin 2013). Still others shy away from the term altogether and focus on the instructional strategy, “Problem-Based Learning” or PBL as their guiding terminology. As the movement toward STEM learning strategies has grown across the U.S. with support of government and industry, several foundational definitions have begun to link these strategies more closely with problem-based learning (Kennedy 2016). Although some schools, especially the early, STEM adopters, focused on project-based



learning activities, schools starting up today more and more focus on problem-based instruction using community needs to drive the context and relevance of problems and projects. Evidence gathered by the National Academies of Sciences shows that the greatest academic change takes place when the instruction is based in real world problems using projects to create a variety of solutions (Honey et al 2014:71).

For existing schools the shift is more difficult. Teachers fear the loss of control in delivery, status in community, and learning new techniques that they will not excel at immediately. Teachers also fear change as a fad, based on recurring cycles of “bandaid” fixes to existing textbook/lecture strategies intended to solve any number of unintentional consequences such as declining achievement, engagement, or behavior. Add to this, the fear of being held accountable for student achievement test scores and the number and magnitude of constraints associated with instructional, cultural and delivery thresholds. The fears increase and bolster resistance, creating constraints that complicate navigation in the approach to a paradigm shift and impede change.

So, how do we help teachers navigate the constraints associated with the liminal tunnel when shifting to problem/project strategies? How do we model partnerships that insure problems and projects resonate with community needs? Finally, how do we bolster confidence in both teachers and students to ameliorate the “wobble” following the shift in threshold concepts? There are no simple solutions, especially when one considers that education is a US\$85 billion industry in the U.S. with approximately 3.1 million full-time teachers (National Center for Education Statistics 2016). For the purposes of this chapter we focus on transdisciplinary problem-based learning (TPBL) professional development, and applied evidence-based research as a means to help educators navigate the constraints and pitfalls associated with the threshold concepts of instructional, cultural, and delivery strategies.

Neither research nor professional development alone can accomplish necessary changes. The following case studies reflect the holistic approach to helping educators navigate a path to change and the needed support to bolster practice with new strategies. The practices and professional development requires a two-pronged approach. First, professional development works best when grounded in established theory to practice approaches that model these strategies for educators. Second, professional development is amplified when informed by evidence-based research that takes into consideration the perspectives of educational stakeholders. Including all stakeholders is imperative if this century’s educational strategies are to align with the needs of its culture. Collecting the voiced perceptions of distinctive stakeholders enables researchers to confirm certain beliefs and misconceptions. Gaining stakeholder insights also informs both professional development providers and policy makers in regard to actionable pathways that empower educational strategies to remain agile and responsive to both the broad universal norms of education and the particulars of regional community needs.



CULTURAL STRATEGIES: INTEGRATING COMMUNITY NEEDS

Since all universal strategies of education are rooted in a cultural context, successful navigation of the liminal tunnel with all its associated constraints and pitfalls requires a holistic approach that includes all stakeholders. Buy-in and shared vision reduce the number of constraints that obfuscate threshold concepts. In his leadership work, Simon Sinek points out that successful buy-in first requires a clear understanding of WHY, well before the delineating the HOW or building the WHAT (Sinek 2011). Transparency in the WHY and the HOW promote acceptance of the diversity of the particulars. The HOW specifically creates a plan of action that multiple stakeholders can get behind and support. The HOW also empowers stakeholders to assume a role that fits their abilities and contributes to the overall success. Finally, the WHAT becomes the tangible accomplishment driven by the WHY. The following discussion explores case studies that demonstrate ameliorating cultural constraints.

The first case study centers on Ohio's first STEM platform school. This urban/suburban, early college high school was formed around meeting regional workforce needs, improving post secondary achievement, and emerging STEM learning strategies. Three partners led the process, Battelle (industry), The Ohio State University (post secondary), and K12 school districts of Franklin County, Ohio. This triumvirate took on the responsibilities of four key components; 1) to bring on partners that could help design curriculum that was responsive to industry needs; 2) to further expand partnerships; 3) to align high school programs through early college opportunities; and 4) to actively market the approach to shift away from traditional educational strategies (Rosen 2016:10). This pilot program empowered the Ohio state legislature to become the first state in the nation to enact STEM as an approved alternative educational strategy to the dominant textbook/lecture strategy (Ohio House Bill 119 2007). PAST Foundation joined the partnership team to help build a transdisciplinary approach in designing problem-based and project-driven curriculum. The program was studied in 2007 in its second year of operation by the PAST Foundation's research division through the support of the Battelle Center for Mathematics and Science Education Policy. The study employed a mixed methods approach grounded in ethnographic rapid assessment looking at the emergence of STEM and the optimization of networks as a primary driver of program design and implementation (Hunter & Agranoff 2008).

Through shared "Habits of Mind" and a systems approach, school administrators, teachers, partners, and students transparently marketed the WHY and the HOW of the instructional, delivery, and cultural strategies. Reminders of the Habits and "Principles of Design" popped up in every classroom, and on every assessment. In short, they became ubiquitous norms in the school's culture. Students and teachers used the Habits — *Critical Thinking, Inquiring Learner, Collaborator, Communicator, Engaged Learner, and Active & Responsive Decision Maker* to benchmark progress and learning. They used the Principles of Design — *Brainstorm, Research & Design, Build, Evaluate, Modify and Share* to articulate



the systematic processes of problem solving and reasoning. Learning that modification is an important part of any problem solving empowered students to demonstrate mastery of concepts over the course of any project or design challenge. Together, the Habits and Principles of Design provided the community with clear benchmarks for assessing progress in projects and products the students undertook to solve problems put forth by industry or the community. Hitting the benchmarks increased confidence levels in both teachers and students.

Although problem-based benchmarks did not rely on textbooks nor lecture delivery, the projects were tied to concepts or educational standards. When students produced their demonstrations of learning, the community was invited to observe and comment, providing an authentic audience. This type of problem/project-based strategy tied to known regional needs with consistent benchmarks, produced demonstrations of student learning that also grew important life skills. With increased confidence the impact of the liminal constraints to full implementation of problem-based learning declined, allowing the entire community to embrace the new strategies associated with the educational threshold concepts.

The confidence of the community supported the acceleration of learning and the whole new look of the school and school day. This support also allowed the school to agilely grow new models. By year three the program created "Learning Labs" for students eligible to attend college. The Learning Labs developed as a mechanism to address real world problems, boost college/career readiness, and provide authentic experiences blurring the lines between secondary and post secondary institutions. Today, five pathways - *Bodies, Design, Digital, Growth, and Energy* - blend high school coursework, college courses, internships, and capstone research, providing authentic learning experiences that are problem-based and resonate with workforce development. The use of Learning Labs as a bridge between community and education highlight the types of responsive adaptation of strategies to contemporary cultural needs. The Learning Labs focus on problem-based learning employing multiple projects to build skills needed to succeed in either future academics or careers. Students are engaged, they attain deeper learning, they demonstrate greater confidence, and there is no remediation required when they matriculate to college or the workforce. The support of industry, the collegial support and collaboration of Learning Lab teachers with one another, and the academic success of the students has instilled stakeholder confidence to maintain and amplify problem-based/project-driven strategies that resonate with regional workforce and community needs.

The positive influence of this STEM school in Ohio has sustained over time. Within the first ten years of its launch, forty more STEM schools have been created (Ohio Department of Education 2017). Each has leveraged the lessons learned from the initial program creating a continuum of successful navigation through the constraints that led to making full paradigm shifts in education. In the decade following the the launch of the first STEM platform school, multiple schools have fully engaged in problem-based strategies and project-based delivery that are tied to their respective community needs. The importance of this growth in STEM programs reflects the increased successful navigation of the constraints leading to



implementation of problem-based strategies and the growing willingness of teachers to embrace the changing strategies to full mastery. The school continues to be studied from various perspectives that examine outcomes weighed against liminal constraints and pitfalls (Han et al 2014). Some of these pitfalls will be discussed later in this chapter.

The second case study centers on a suburban school district that reached out into its community to take the pulse of perceptions around the shift in educational strategies from traditional textbook/lecture to problem-based learning. This case study also demonstrates that cultural needs drive all universals, and understanding perceptions of the community helps educators explain the WHY and HOW as well as recognize community needs. This information drives the WHAT and by sharing it back out with the community grows support and builds confidence in the new strategies.

This particular suburban school district launched a five-school STEM initiative. The schools span all K-12 grades with two STEM high schools, two STEM elementary schools, and a STEM junior high school. Two of the schools were new, and three represent flipping existing schools. Without question the two new schools received community support, but the three existing schools struggled to make the shift. This is in part due to self-selection of the teachers at the new schools and clean slate in establishing expectations and strategies.

Five years into the STEM shift, the district suffered a teacher strike. When school resumed, the PAST Foundation worked with the five school administrations to create a community survey and a teacher survey that would help inform and guide the transition to full implementation of problem-based learning strategies. Online surveys solicited responses from the parents of the STEM school students at the STEM designated schools. The qualitative data collected was analyzed both for the individual schools, as well as for an overall view of the STEM K12 feeder system (Patel and Hunter 2016).

INSTRUCTIONAL STRATEGIES:

INSTRUCTIONAL LEADERSHIP NAVIGATING LIMINAL CONSTRAINTS

Instructional Strategies require leadership that level sets new vocabularies and guides faculty in understanding the WHY and HOW of taking theory to practice. Instructional strategies speak to the pathway of achieving deeper learning and goals that these strategies aspire to achieve. Instructional strategies are tightly linked to delivery strategies; however, one without the other truncates learning. In transitioning from textbook/lecture strategies to problem-based learning it is essential that school leadership and community recognize teacher learning curves. This involves providing guidance that first helps teachers navigate around constraints leading to the transition, followed by support that empowers teachers to gain confidence in the new strategies and tools.



In the prior suburban case study (Figure 3) the data reflects both the community's perception of changes resulting from the new strategies, as well as the responsive leadership guidance that created stakeholder buy-in across students, teachers, and community. In order to give stakeholders an understanding of WHAT problem-based learning looks like, leaders need to embed information on HOW these new strategies are used in various forms of outreach. They also need to showcase HOW to implement the strategies in ways that everyone can experience. Responses from all stakeholder surveys, interviews, and focus groups shows that support of the community helps grow confidence and accelerates transition.

The importance of the role of leadership around successful implementation of instructional strategies cannot be overstated. Numerous qualitative and quantitative studies have focused on the influence of school leadership. Without doubt, leadership provides critical guidance and support in shifting paradigms related to universal strategies (Leithwood et al 2004). Familiarity of traditional textbook/lecture strategies in the U.S. often leads school administrators to ignore instructional leadership in lieu of focusing on the immediate needs of facilities and organizational management. In a 2004 review of research around successful school characteristics, instructional strategy falls at number nine among the top ten, just above extra curricular activities (Leithwood et al 2004:31, 56). Programs were brought in to enhance the strategies but the underlying instruction and delivery remained unchanged, thus sustaining teacher perceptions of "add-on" or short-term fad. Teachers continued to use textbooks to guide their lectures and set a pace throughout the academic year, hampering true response to the needs of surrounding community and workforce.

A shift in strategies requires leadership to examine the differing threshold concepts and recognize both the constraints to adoption and pitfalls of mastery. Problem-based learning is driven by real world issues and projects are used to explore the underlying concepts that help identify and create possible solutions. This represents a different set of threshold concepts in regard to instructional, cultural and delivery strategies not simply as "add-ons." When leadership owns the new vocabulary associated with problem-based learning strategies and begins embedding this vocabulary in everyday interactions with the faculty, they lay the foundations for change and establish navigational cues that help overcome constraints and endorse movement through the liminal tunnel. In short, they recalibrate the importance of the strategies.

Teachers look to leadership for these clues. In a study of urban STEM feeder systems, teachers from kindergarten to high school consistently tied success in navigating constraints and mastering new strategies to whether or not principals shared a common vocabulary with the faculty, demonstrating understanding of the pitfalls of implementation (Hunter et al 2014:8). In seeking leadership, teachers are asking for guidance and support. When leadership changes before the transition is complete, teachers



are often left to either navigate the transitional constraints by themselves and/or face pitfalls alone. The result, more often than not, is retreat to the older more familiar strategies. However, when the transition is complete the faculty can and will plot a pathway to sustained transformation continuing to grow full implementation of culturally embedded problem-based learning strategies in the school (Smith et al 2013). In these instances, incoming principals either develop or leave in place strong teacher driven leadership. In teacher led transition where the strategies are clearly articulated, both new administrators and faculty are more easily brought on-board. However, this does not in any way undermine the importance of leadership when it comes to instructional, cultural and delivery strategies (Stronge et al 2008). In a 2008 study, Stronge and colleagues point out that in the evolving landscape of education of the 21st century, “leading instructional efforts in a school has evolved into a primary role for school principals” (Stronge et al 2008:1).

Leadership must also lay out expectations that provide impetus to change. From the case study analysis of teacher feedback in both urban and suburban STEM study, school leadership was quickly able to discern if their aspirations were being adopted by their faculty (Hunter et al 2014, Patel and Hunter 2015). Feedback enables leadership to rapidly modify communication, and increase emphasis on collaboration to achieve goals. This type of feedback reflects the importance of qualitative data collection versus quantitative absence/presence types of data providing insights on actionable pathways that strengthen leadership and thus amplify response. Among the suburban district leadership that used feedback from both community and teachers to tailor practices and help navigate the liminal tunnel of constraints and pitfalls, data showed the greatest gains in community support (Figure 3).



Figure 3. Building confidence with tools and support.



At a Texas suburban school district, leadership focused on providing all faculty with intensive additional post secondary mentorship and support (Hunter 2009:10). They pinpointed math as the content area having the most pitfalls impacting successful mastery. To ameliorate the pitfalls and bolster teacher confidence the school entered into a partnership with Texas A&M University. Through the partnership teachers attended college courses before actually implementing problem-based strategies in the classroom. This support strengthened literacies in math and language arts, impacting confidence and ultimately student achievement. Increased confidence along with the ubiquitous use of vocabulary around principles of design and habits produced a strong community of practice that was reinforced by the support of leadership. By taking on the role of instructional leadership this district's leaders holistically impacted all the elementary grades and were also able to successfully embed the strategies from first grade through fifth grade, before turning their attention to transitioning the middle school and high school grade levels.

Leadership in instructional strategy takes on a particularly important role when transitioning to a new set of strategies. This requires an increased amount of professional development for leadership as well as teachers over multiple years. A growing body of data collected around stimulus grant funding for schools and innovative practices reveals that leadership professional development at the beginning of the project is vital to success. Furthermore, leadership professional development is only successful when the planning team either has an administrator involved or a leadership team with decision-making authority. In each instance the teams that developed a plan, designated resources needed to implement the plan, defined a timeline, and tied the project to a budget were able to successfully implement the project and also leverage support from colleagues and community (Smith and Deaner 2014; Patel and Hunter 2015). These stimulus projects have been the impetus to create bundled professional development around leadership, where teams walk through gathering asset maps of their schools and/or districts, then use that data to present to colleagues, community and businesses around the WHY, HOW, and WHAT transition to problem-based learning will take place. As teams and leadership are able to articulate the purpose (WHY), they are able to meaningfully develop the pathways (HOW) to produce numerous outcomes (WHAT). The desired outcomes can never be fully realized without a clear sense of WHY. Allowing teams and leadership space and time to develop varying HOW's or pathways helps mitigate the liminal constraint of believing there is only one "right" solution to transitioning into new instructional strategies.

DELIVERY STRATEGIES: EMBEDDING CONTEXT IN PROJECTS

If cultural strategies for problem-based learning must engage whole community, and transitioning to new instructional strategies of problem-based learning requires strong and decisive leadership, then the delivery strategies are the domain of the teachers. It is through the delivery strategies that problem-



based learning can achieve transdisciplinary status and be enriched through the passion and inquiry of teacher/student teams. However, transitioning from lecture to project-based delivery strategies takes work. Projects must be tied to a problem and they must be managed in terms of time and sequential benchmarks, just as any project in any industry. It is a delivery system that responds best to facilitation by teachers

rather than only lecture, and projects tied to real world problems often have multiple outcomes. Gaining confidence in managing projects and the associated concepts or standards takes time and practice. Once a teacher commits to delivering problem-based learning through associated projects there is a period where teacher confidence needs bolstering as they navigate the pitfalls of delivering new ways of teaching and learning. In the ongoing research and response, PAST has determined that one effective method of assisting navigation of constraints and support through the early adoption phase is through regular, compact online courses and virtual professional development that can address key aspects of transition. The courses combine asynchronous and synchronous delivery. The asynchronous materials allow teachers to engage and revisit the strategies at their own pace and on their own terms, which allows for greater reflection and synthesis. The synchronous components provides an easily accessible, collaborative environment. Collaborative brainstorming builds confidence, creates viable solutions, and diminishes the wobble in the early phases of mastering the new strategies.

In a recent study chronicling the growth in confidence with problem-based learning strategies, teachers in a rural Ohio school district responded to questions about time and resources, developing instruction

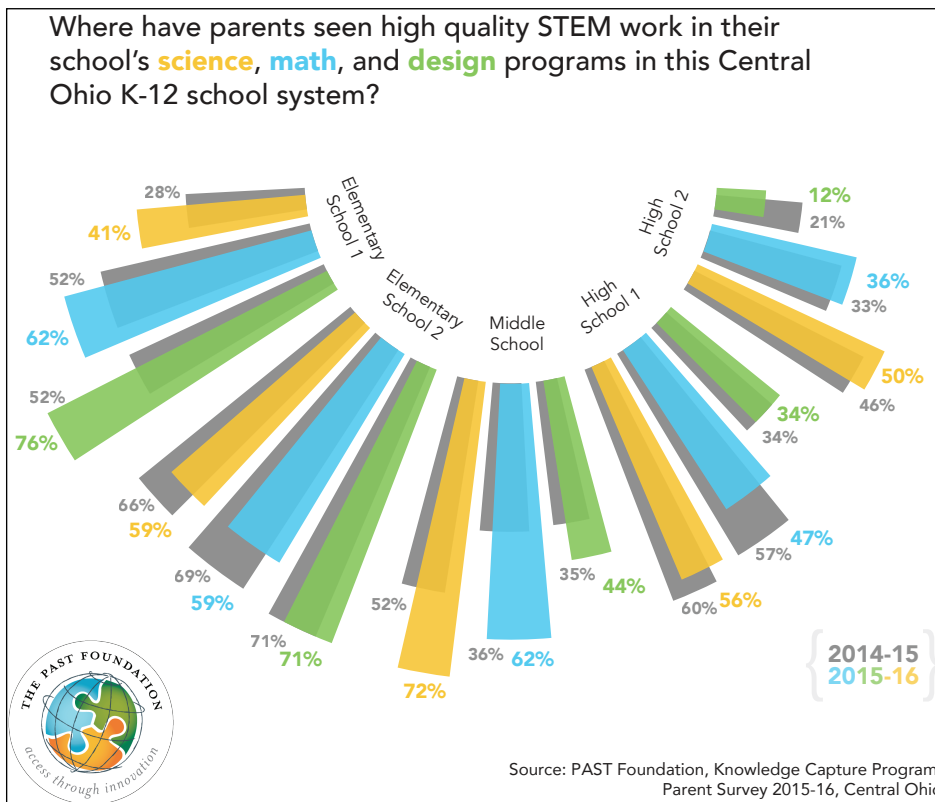


Figure 4. Listening to community voices to help grow confidence.



and teaching tasks. Overall support produced growing confidence even within a short time span (Hunter, Cohen and Galloway 2017). The graphs in Figure 4 also help pinpoint the pitfalls that challenge confidence. In the last graph on *Developing Teacher Tasks* (Figure 5), teachers relate that they are still struggling with “Backward Design” which is probably the most divergent characteristic of problem-based learning, especially when teachers focus on a transdisciplinary approach. Textbooks are laid out in a chapter format leading both teachers and students through a set course of learning and ending with a summative assessment. When teachers switch to problem-based strategies they begin with a problem and a series of projects that will help solve for the problem. For example, a recent group of urban teachers posed the question to their students, *How can innovative agricultural practices feed a growing population?* Next, teachers backmap the project pathways, creating multiple projects and sub-questions that explore the broader problem from multiple aspects. Starting with the culminating demonstration the teachers work backwards to the initial presentation of the problem, filling in criteria, benchmarks, expectations, and concept alignments. For the question cited above, the students will explore horticulture, water catchment and management, as well as marketing the produce. The culminating products will include a sustainable community garden that blends technology with agriculture, and a Chef’s Market that pushes fresh produce out to the surrounding restaurants and kitchens. It is a checks-and-balance system that helps insure that the product and the projects clearly relate to the WHAT and the HOW of the WHY.

Problem-based learning is tied to issues that resonate with community. The problems and projects any class takes on may place teachers in the unknown territory of having to seek expertise and partnerships outside the school building and outside their general knowledge. This becomes a pitfall in delivering relevant learning opportunities and can undermine the confidence of a teacher accustomed to possessing the majority of knowledge sourced from a textbook and confined to the classroom. Providing the

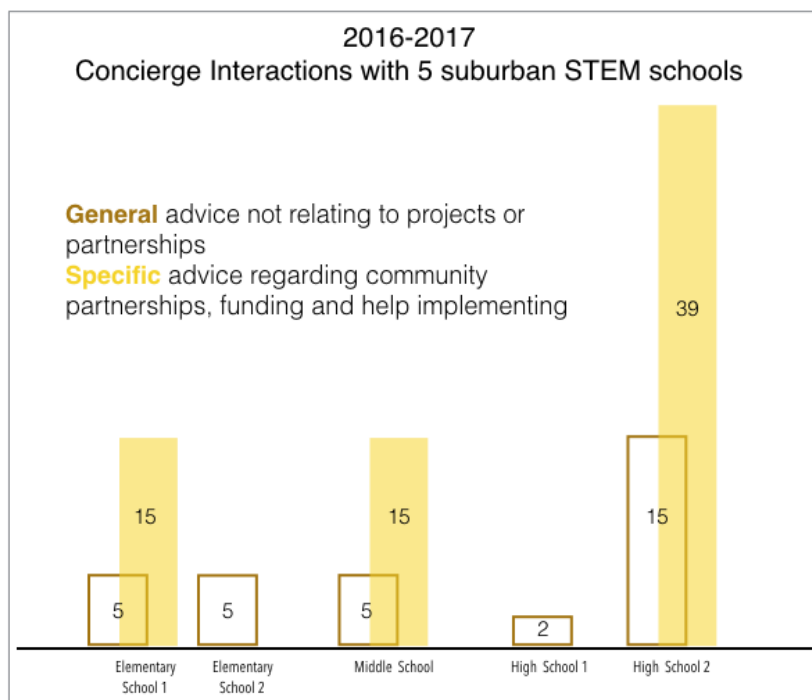


Figure 5. Concierge support is both general and specific tailoring support to meet the needs of the teachers and administrators.



bridge for teachers to access community expertise is critically important in building confidence for rigorous and robust projects that relate to real world problems. At PAST, this part of professional development is known as “Concierge,” where teachers can ask for help outside their spheres of knowledge and mentors model how to reach out and communicate desired expectations. *Where do I find someone knowledgeable in health care? Who can help me find out how to build robots? Where can I get donated supplies for our project?* In the last academic year, over 100 requests have been fielded helping teachers create and build partnerships (Figure 5). By modeling how to reach out for information teachers gain the necessary skills to repeat this type of collaboration in the future and strengthen the connections between cultural and delivery strategies tied to community resources.

An important resource to tap for helping teachers transition is their own passions. Most teachers have interests outside of the classroom. Getting teachers to tap into their own passions to deliver learning is an effective way to bolster confidence. A teacher might be an avid gardener or enjoy sports statistics. Personal passion radiates enthusiasm and also eases the transition in tying projects to problems. Sheer enthusiasm can carry a teacher across numerous pitfalls and provide a multitude of projects of interest. One of the best examples comes from a kindergarten teacher in rural South Dakota. The teacher is a passionate bird watcher. When challenged with transitioning to problem-based learning this teacher made the conscious decision to focus her student learning around the issue of, “How do we insure that birds continue to migrate through our town in the future?” Each year the kindergarten students begin by learning facts about birds that migrate through their town and writing down the information in a book that they publish. By learning how to solicit funding sources and ornithology expertise, this teacher has outfitted her class with auto focus binoculars and garnered expertise from across the nation. The students can identify over 100 bird songs and have presented annually at the regional ornithology conference. Working with older 9th and 12th grade students the kindergartners designed habitats for the local bird species and built bird houses. Tracking migration numbers students hone mathematic skills well beyond their grade level. The discussions in the classroom are rich and the students asked if they could forego afternoon naps to listen to stories about birds. This teacher’s passion ameliorated a number of pitfalls often associated with the transition between strategies, leaving the teacher to wonder if the transition was going in the correct direction because problem-based teaching did not seem as hard in application as imagined coming into the transition. These kindergarten students learn concepts associated with reading and writing, technology, science, math, and geography all through a keen awareness of birds in their hometown. As the teacher pointed out in a recent interview, “I don’t expect the kids to become ornithologists but to become excited about learning and be able to transfer this excitement to other subjects and problems” (Smith 2017). Thus using natural enthusiasm for a topic tied to a culturally relevant issue is another way of ameliorating the negative affects of the liminal tunnel in the process of transition.



Sometimes the pitfalls in the liminal tunnel are not directly tied to the transition between strategies but rather to the dynamic skill set of a teacher. One teacher may be a great innovator, while another is very detailed oriented. By creating hybrid teaching teams that deliver all core content concepts (science, language arts, math, and humanities) simultaneously within problem-solving, the team can capitalize on individual teacher's strengths and together provide robust learning as well as help each other across the pitfalls of delivery. Hybrid teaching teams have a great deal of success when using problem-based learning strategies since these strategies negate the need to have a dedicated amount of time to silo learning. As the projects solve for the problem, students draw on the concepts they need from all core subject areas garnering deeper learning and creating more complex and sophisticated solutions.

For the last five years, a corps of teachers have piloted a hybrid teaching model in rural South Dakota (Smith et al 2016). Combining strengths of the teaching team in delivery has accelerated the transition and relieved a number of different fears that otherwise would have created numerous transition pitfalls for individual teachers. This type of transition requires very targeted professional development to help establish a new set of practices and perspectives in modeling design thinking and collaboration for each other and the students. Teacher transparency and deliberation will model design thinking allowing students, unaccustomed to seeing modification unfold before them, better understand what they are experiencing. Being able to clearly articulate design thinking processes for students bolsters confidence among teachers reinforcing foundational components of problem-based learning. Being able to reach out for assistance among the team in real time to better facilitate all styles of learning (verbal, visual, auidial, and logic) will build gains in student engagement and further bolster teacher confidence in delivering robust problem-based learning.

Concerted, deliberate and sustained professional development can ameliorate the constraints encountered when approaching a transition and the pitfalls in the early phases of learning new delivery strategies. Without directed professional development and mentoring, transitions are often long and protracted, lengthening the liminal tunnel associated with the threshold concept. In a number of instances the lack of professional development at key points in the transition frustrates both teachers and community. Continuous "cherry picking" of teachers who are adapting faster to the new strategies can also result in setting the whole school back to restart. The WHY and HOW are both lost. Frustration and lack of success can lead to full stagnation. Stagnation, especially in the early phases of learning the delivery strategies, leads to a return to older, more familiar strategies regardless of problem-based learning's effectiveness. In these instances problem-based learning strategies are abandoned.

Over the years, PAST has witnessed protracted transitions and full stagnation. For example, continued PBL mentoring for the STEM urban/suburban early college school after the initial teaching cohort moved across the threshold concepts of problem-based learning was not supported across all grade levels, nor were new faculty on-boarded with problem-based strategies. The underlying structure of open space



and blurring the lines between secondary and post secondary learning remain, but full implementation of problem-based learning has stalled. Ten years after its launch, this STEM school's problem-based learning strategies exist in sporadic pockets throughout the grade levels and the Learning Labs. The majority of courses tend to be a combination of more traditional strategies that still rely on rote memorization with short-term design challenges interspersed throughout the academic year. Few teachers and even fewer students can articulate the Habits or the principles of design. Reviewing this school's strategies a decade out illuminates the importance of continued professional development for teachers as they learn to master and sustain the new delivery strategies, while continuing to grow with the culture of their community. In the example of the urban STEM feeder system, transition has all but been abandoned. Annual movement of over 40% of teachers to other schools has significantly impeded any progress, resetting several schools chronically back at the entrance to the liminal tunnel of new teaching strategies. In these instances few teachers received enough support or direction to successfully make the transition. Without support that enables mastery of the new strategies, the retreat to comfortable strategies, regardless of the strategy's effectiveness, pushes teachers to abandon new threshold concepts. Yet, with professional development that is responsive to the universal strategies and particulars of individual communities, the constraints and pitfalls of these educational strategy thresholds can be successfully navigated, bringing deeper learning to students and confidence in problem-based teaching practices to educators.

LESSONS LEARNED: CONCLUSIONS

With over 17 years of data collected about and around STEM problem-based learning of the educational landscape in the U.S., the PAST Foundation has identified certain patterns of constraints and pitfalls associated with changing educational strategies as they emerge. PAST's School Design and Research teams are committed to defining and understanding these benchmarks, and finding pathways and motivations that help usher educational stakeholders through the liminal tunnels associated with the new strategies. The aspiration of this work is to promote, amplify, and accelerate the transition from traditional instructional, cultural and delivery strategies to strategies that better respond to the needs of this century's culture and workforce development. As the new strategies demonstrate that they are aligned to the needs of community, training of new teachers and additional training for existing teachers will establish these strategies as the norm.

Collecting and analyzing data around perceived constraints provides actionable pathways for professional development. In turn, the PAST School Design and Research teams are able to support administrators proactively engage community and lead faculty in the transition through the liminal tunnel associated with problem-based strategies. Opening avenues for community partnership with educational models, while collecting feedback establishes alignments and pipelines that genuinely link



learning outcomes with particular cultural needs.

Understanding constraints of all stakeholders enables professional development to target specific fears by providing shared vocabulary for new strategies and flexible courses for acquiring new teaching tools. Recognizing pitfalls as benchmarks for gaining confidence in new strategies guides professional development in creating targeted, teacher support around specific components such as assessments, partnerships, and project management. Understanding pitfalls also guides building collaborative environments where teachers can share successes and seek advice from peers about overcoming those pitfalls.

As U.S. public and private educational systems continue to shift paradigms in instructional, cultural and delivery strategies, new models and older practices will organically grow accelerating change to respond to cultural needs. The speed of cultural change directly impacts the types of literacy required of education, as well as the agility of educators to respond. Thus continued study of constraints and pitfalls associated with threshold concepts in order to facilitate transition and bolster new habits is imperative if we are to effectively prepare teachers and educate the children of this century.

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This report is part of ongoing conversations and brainstorming focused on helping educators make the paradigm shifts towards transdisciplinary problem-based instructional and delivery strategies that are culturally relevant for education today. Sheli Smith is the Chief Academic Officer of PAST heading up programs and research. Monica Hunter directs the PAST research division, known as Knowledge Capture, focused on the emergence of Design Thinking and workforce development in today's educational landscape. Kat Deaner directs the PAST School Design team providing TPBL professional development and school re-design to educators and communities around the world both online and onsite. Ketal Patel is part of the PAST School Design team in Ohio.