What have we learned in the 75-year evolution of our profession to implement technology as a subject and as a unique approach that supports Integrative STEM teaching and learning?

a 75-year personal perspective on implementing technology education as a subject

by Ronald D. Todd

“This has been a rather long but exciting journey.”

I will attend to the above question by examining selected activities and efforts that: (a) have shown some success in enhancing the professional attention to and adoption of technology as a subject and Design, Engineering and Technology (DE&T) as an approach that supports Integrative STEM teaching and learning, and (b) have been shared through the Pupils Attitudes Toward Technology (PATT) research publications and the ITEEA program of curricular and instructional development.

Cooperation—Tension—Competition

The time leading up to the establishment of our profession was shaped by the interaction of the forces of Cooperation, Tension, and Competition. Although the roots of Industrial Arts (IA) and Technology Education (TE) could reach back into the 1800s and beyond, we'll look at selected key developments in the early 1900s that continue to influence our profession. First was the effort, or “tension,” to replace “manual training” with “industrial arts.” The key inadequacies of manual training were detailed in the 1923 publication *Industrial Arts for Elementary Schools*.

During efforts to replace manual training with IA, a different form of tension and competition was introduced via the Smith-Hughes act of 1917. The Act provided philosophy, guidelines, and funding for vocational education and introduced the tension of opposing views regarding technically based education. The Act contributed to the isolation of vocational education from other parts of the comprehensive high school curriculum. The influence of the Act eventually led to the current Perkins Act.

In addition to the forces of tension, competition and cooperation, this article is shaped by two overarching ideas. First, technology as an arena of human endeavor places value on and demands for innovation and change. Second, the evolution of TE as a profession has often been slowed and shaped more by the anchor of its past than by the power of innovation and change so prominent within technology.

The stage is now set to share with you some my experiences that will shape the answers to the questions above.

My Early Years *(setting the stage for engagement and commitment?)*

I grew up in a small town on the Ohio River that had declined economically during the depression—money was tight with wages *(if you could find work)* at around $1.00 a day. I got a few pennies for chores, so pursuing my hobby of making things was seriously limited— but I learned how to improvise and scrounge.

I found some of my dad's tools in the basement—and got my first lesson in safety. I had trouble holding a full-size hammer properly when trying to drive a nail into a hard piece of wood. During one inaccurate swing of the hammer the nail ricocheted about, bouncing off my forehead. It made quite an impression (pun intended).

Dad's toolbox and tools were only available to me when he returned home on the weekends from building army barracks. However, resources remained scarce, making it difficult to build things—and prompted me to hone my scrounging skills.

After the war, we moved to a small, rather dilapidated farm. When other farmers were buying tractors and modern equipment, Dad bought horses and the essential horse-drawn equipment to work the farm—it was like traveling into the past—at least back to the mid-1800s.

In eighth grade, I transferred to a much smaller school with very limited, and uninteresting, course offerings. In 1948 an announcement was made that a shop teacher had been hired for the coming school year. I had looked through the windows of the shop and had seen the interesting stuff inside. I quickly signed up for my first shop course.

As a sophomore, I was delighted to have a course that allowed us to actually "do" something—in my case, woodworking, and mechanical drawing. I reveled in gaining drawing skills and building furniture. I was pleased, as a junior, to receive the Outstanding Achievement Award in shop.

I wanted to become a shop teacher and wanted to gain additional knowledge and skills in drawing. As the only student with this interest, I submitted a request to take on an individual project in drawing but was denied by the shop teacher. Although I decided to drop shop, I still consider it my first important course providing (a) knowledge and skills I could use, (b) an open door into my future career, and (c) a model of teaching that I did not want to emulate.

The 1950s *(preparing to become an IA teacher)*

After graduating in 1951 with honors, I worked until the end of the year and then registered as a freshman. Upon arrival on Kent State University's campus, I was amazed by lots of things. It took a while to get comfortable and confident with 4,000 students, as compared to my Grade 1-12 school with only 212 students, total!

Exciting for me were the shops and the ongoing activities in the new IA building. I became a sponge and soaked up everything. I enrolled in any and all skill courses as well as workshops and activities ranging from leather working to flying to singing and playing in the University band to teaching. I realized there was a different kind of thinking required of me in the one and only design course offered in the IA program.

I graduated with honors in math and IA in June 1956. At that same time, I received my Army commission and two weeks later was on my way to Fort Sill, Oklahoma for basic artillery training. That training was difficult, but I did well, applying math and finishing high up in the class ranking. Next, I got orders to report to Fort Hood, Texas where I joined an artillery unit responsible for training new draftees. When my time there completed, I requested and got orders for an assignment in Germany with the 4th Armored Division.

My work in Texas and Germany as a training officer was demanding, but it helped me develop useful teaching and planning skills. Fortunately my duty assignments required travel in Germany and France, and I was also able to take two weeks of personal leave. It was during these trips that I caught the bug for international travel and gave serious thought to making the military my career. But I wanted to teach, so when my tour of active duty was complete, I returned to the States and took a high school teaching position.

A Return to Teaching and a Change in Plans

I found a job in a school with only one shop teacher at the high school and one at the junior high school. I spent many days that summer cleaning up, servicing the machines, and much more before classes began. My return to teaching was every bit as exciting and fun as I hoped. However, after reviewing that first year, I began to question if, at its best, it would be adequate for an extended career? I knew that my answer was "no!"

1960s—An Exciting Time in Education *(little did I know that my life and plans were about to change—dramatically!)*

My dissatisfaction continued into 1960, my second year of teaching, so I arranged to meet with Dr. Delmar W. Olson, one of my favorite undergrad teachers, and Department Chairman. I indicated that, even after a few years of successful teaching, what I was pursuing seemed to lack direction, substance, and purpose. Dr. Olson shared his ideas of the direction that IA should take and the importance of instituting "technology as the content base" for our subject. I was hooked and asked where I could visit such a program. His reply was short and to the point: "*We need young people, like you, to implement such technology-oriented programs!*" This simple statement, made 60 years ago, resulted in serious and long-term changes in my professional and personal life.

I made the necessary plans and, in 1962, returned to KSU for further study and work as a graduate assistant. In my first course with Dr. Olson, I worked with Jim Durkin, Doug Stallsmith, and Dave McCrory to blend our efforts to develop a conceptual framework of technology. We spent a lot of time together discussing what we had discovered in the resources from the university and regional libraries, but also a wide range of current technology magazines and older engineering books from local industries and businesses. These diverse materials introduced us to concepts that helped clarify selected aspects of technology.

We were learning more about technology and, at the same time, discovering the role that concepts could play as teaching and learning tools. We realized that, without concepts, there was little chance that students could transfer their knowledge to other circumstances. A new goal was to help students experience, understand, and use key concepts of technology. At a beginner's level, simple concepts could help students understand more about the common tools they were learning to use.

Our interest in this approach was to help our students transfer what they learned to new and unusual circumstances. The reactions of some of our contemporaries to this approach were amazing and disturbing.

There were many heated arguments at the local and national levels. A major one was the reaction to introducing new skills and content related to problem solving—that would help set a foundation for developing additional skills in design and problem solving. Some arguments were in-your-face direct, while others were less direct, but effective as blocking or diversion strategies. "Why talk about problem solving all the time, everything is not a problem, what about the opportunities?" These arguments made it difficult to discuss implementing a progression of skills, from a beginner level on to design and problem solving and later to engineering-oriented design projects. These arguments seemed to be reaching a professional boiling point. What would be the response to the introduction of more comprehensive plans?

We were able to harness that tension and conflict to keep working on a comprehensive plan for organizing and connecting classes and activities across the curriculum and throughout the school day, while helping students become aware of the "world of work." The result was our initial curriculum model we called the *Enterprise Approach.* The sketch below, from the late 1960s, served as a map for linking our classes together and for integrating our activities with other subjects. With it, we were able to develop a high school program that created a lot of interest and excitement for the students and for the teachers.

These early efforts did not go unnoticed. In 1964, Dr. Jake Stern, Professor at the University of Illinois, and a co-director of the *Functions of Industry* project, heard of our efforts and wanted to know more. Jake's visit was a high point during our early struggles. We held an extended discussion about what would be included in the ninth grade *Elements of Technology* program. Jake shared some insights from his study of technology that were similar to ours, which convinced us that there were identifiable concepts that could enhance the "elements" of technology and help us continue our work. This simple supposition spurred on that work, lasting for over 20 years, and resulting in this more robust "framework of technology" that included more attention to the design process, impacts, and the different aspect of human involvement.

The foundational work on the framework began in the 1960s, so we were too inexperienced to pursue Federal funding from the U.S. Office of Education for curriculum and program improvement. We did learn about other initiatives including the Industrial Arts Curriculum Project (IACP), the American Industries Project, and the Maryland Plan that built upon Don Maley's earlier work. We learned of USOE funding of a National Conference on Elementary School IA to draft statements of definition, philosophy, and approaches, providing a meaningful context to learn more about Elizabeth Hunt's *Technology for Children* (T4C) project. Unfunded efforts included the publishing of D. W. Olson's book *Industrial Arts and Technology*, P. W. DeVore's efforts in establishing *technology as a discipline*, and the work of our Ohio team.

The fever of change and improvement was catching. On completing my M.A. in Industrial Education, Dr. Olson offered me the exciting challenge of developing and teaching an off-campus, *Technology for Elementary Teachers* course. After investigating, I proposed that it be taught within an historical context, as elementary teachers had a "History of Ohio" requirement. This allowed me to take advantage of my own interest in history and to draw upon Libby Hunt's T4C experience. The responses to the course were positive.

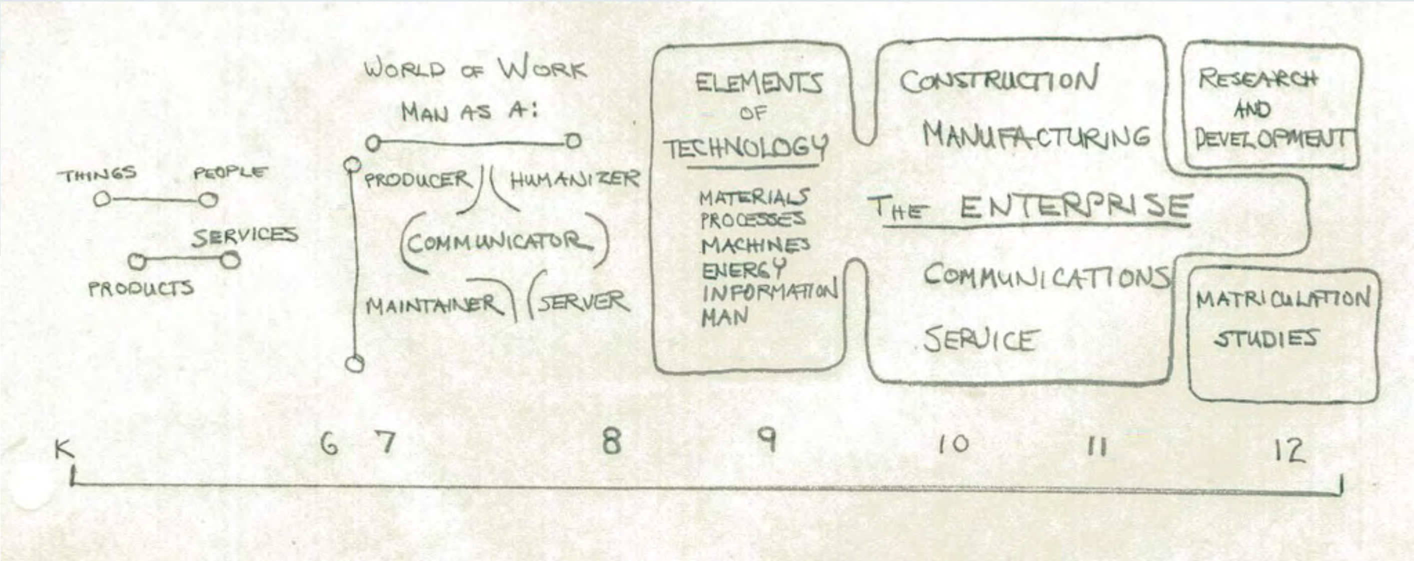

Figure 1:
Enterprise Approach Curriculum Model

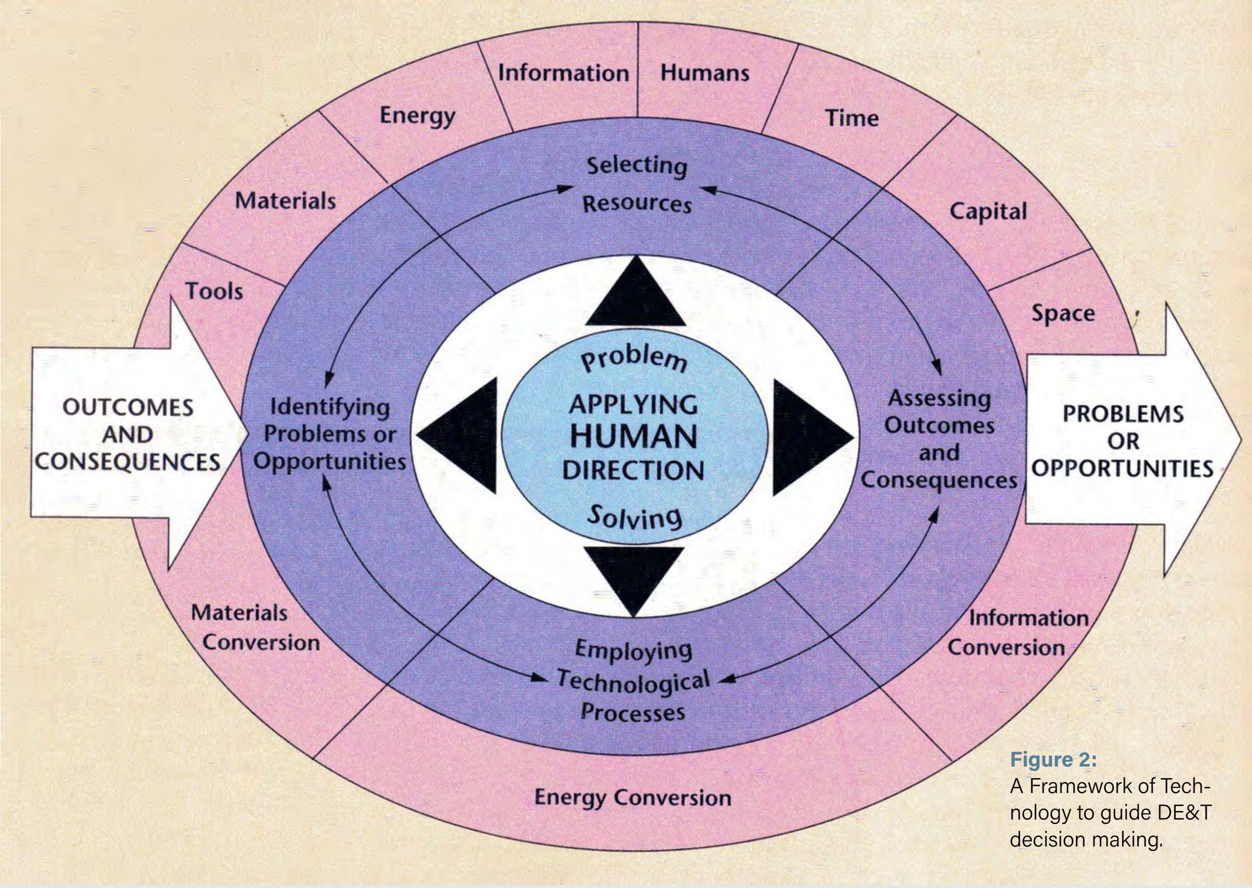

Figure 2:
A Framework of Technology to guide DE&T decision making.

The following school year Jim Durkin and I teamed up to join the Indiana State University faculty. We were hired to support Dr. Lewis Yoho, Dr Ethan Svendsen, Dr. Elmer Ciancone, and others to implement an *Orchestrated Systems* approach that Dr. Yoho had planned. This was a fun time even though it was filled with a lot of tension, a good bit of cooperation, and more than a little competition.

Two years later we returned to Cleveland to join the Educational Research Council of America. We co-directed an *Occupational Education for All* program that had just been mounted. While at the Council I met my future wife, Dr. Karen (Pritchett) Todd, who also became my mentor and early childhood consultant. With her encouragement I enrolled in the doctoral program at Case Western Reserve University in the fall of 1968. It was a great choice as I was able to pursue several of my interests, namely curriculum design and instructional planning, and also delve into the history of technology.

The 1970s *(continuing the search for what our professional field should be)*

In 1972 I was invited to interview at New York University. After a lot of thought and discussions with Karen, we visited NYU and accepted the offer. I joined the NYU faculty as Chairman of the Vocational Education Department, quickly to be renamed Technology and Industries Studies.

The 1970s continued to be a relatively quiet time for TE. However, in 1971, Dr. Sidney Marland, as Commissioner of Education, established a Career Education initiative within the USOE. In this same period, funding for IA was included in the Federal Vocational Education Act, an action that would have an exciting impact for NY State ten years later. In the mid-1970s a small team at NYU secured funding for a project to retrain engineers to teach IA. It was an interesting project and we benefitted from the experience, perhaps more than the participating engineers. We discovered how difficult it would be to implement a career-change effort, especially with limited time and resources.

In 1979 professional activities started to get interesting with funding for the development of first *Standards for IA Education*. We believed that developing such standards would be helpful in future teacher training initiatives as well as curriculum and instructional materials development.

Having IA included in the Federal Vocational Education Act had an enormous impact for NY State now, ten years later. The importance of the NY State-sponsored curriculum development effort with federal funds should not be underestimated. NY State played a vanguard role nationally, led by Mike Hacker, in implementing the Training of Technology Teachers (TTT) project. The effort focused a lot of attention, energy, and talent on determining what TE might look like and what activities would be provided for middle school students. The implementation efforts of Clark Greene and Henry Harms in their teaching and publications helped establish TTT across NY State and then beyond.

Looking Beyond Our Borders

In preparing for the TTT project we studied some of the early materials developed in England labeled Craft, Design and Technology (CDT) as we developed the TTT unit on problem solving. As we learned more about CDT, during and after the TTT development phase, we agreed to pursue our investigation further. This took several forms; Mike Hacker took the first of several trips to England and Pat Hutchinson secured a Fulbright Scholars award that supported a year of study in the U.K.

I expanded our Technology Abroad program at NYU for the following summer, providing the opportunity for interested TE teachers from the US to visit selected technology-oriented museums in Germany and England, and to come into direct contact with CDT teachers across the UK. The timing was terrific as we found the UK was going through the process of morphing from CDT to a program called Design and Technology (D&T), similar to our own transition from IA to TE. Additionally, we found an impressive range of teaching and learning materials and identified several colleagues who helped establish a US/UK team that laid the foundation for the US/UK Design, Engineering and Technology Collaborative Initiative. www.iteea.org/170371.aspx

The 1990s *(pushing the envelope and stretching the boundaries)*

Our profession has increased its international engagement over the past three decades, especially after collaborating with PATT leaders. We have benefitted from this affiliation by sharing materials, projects, practices, and problems. We have broadened what we know and what we might do relative to technology and STEM education. We have heard regularly, "our world is shrinking" so we must become proactive in considering the role that TE plays in dealing with the problems and the possibilities that we continue to face.

Turning more attention to the history of technology would be another means of enriching our field of professional endeavor. The museum visits that became a key part of Technology Abroad course resulted in helping teachers and students alike understand the seeds, roots, and growth of technology. Such visits and study can help teach courses like the History and/or Evolution of Technology for technology teachers.

Other benefits can be discovered in the history of technology. I was bothered that science colleagues often considered technology simply to be "applied science." That may be the case in some circumstances—it may not be inaccurate, but it is inadequate. Viewing historic events from a technological point can bring accepted ideas into question.

We can imagine that there are examples of technological advances that have preceded or at least been the driving force for understanding the related science. These instances could have potential for removing the silos of STEM and illustrating the integrated and integrative nature of STEM. Even in history there is "Competition—Tension—Cooperation" between science and technology.

Another benefit of the international *Technology Abroad* program was time spent with outstanding teacher educators, supervisors, and classroom teachers in the UK and beyond. We dreamed about finding funds to get some collaborative efforts going in the US. We reached out to continue sharing our ideas and interests with colleagues in Virginia.

The 2000s *(moving into a new and uncertain century)*

With the start of a new century, significant change can be expected. The 1990s had set the stage for what followed early in the new century, namely the increase of interest in engineering-oriented initiatives, particularly technological literacy and STEM. The first of these initiatives was funded by the N.J. Commission on Higher Education to develop *K-12 SMET* materials and approaches in *Exploring Design and Engineering (ED&E)* for middle and high school students. This represented a major effort, with five units for middle school and four for high school. These materials and experiences helped the US/UK team support the *Engineers of the Future* initiative at Buffalo State College.

Standards for Technological Literacy (STL) Launched

In the 2000s, ITEA was fully engaged in sharing *Standards for Technological Literacy (STL),* an outgrowth of the Technology for All Americans Project coordinated by Dr. William Dugger. Details on the scope of this project for the previous 20 years can be found at: *www.iteea.org/TETApr18/130841.aspx*. *STL* was developed from 1996 to 2000 by ITEA and was revised in 2002 and 2007 (ITEA/ITEEA, 2000/2002/2007). The National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA) provided grants to help ITEA develop *STL*.

Engineering byDesign™ Launched

Engineering byDesign™ (EbD™) was established in 1999 through ITEEA's STEM Center for Teaching and Learning™ (STEM CTL™). EbD™ is built on the belief that the ingenuity of children is untapped, unrealized potential that, when properly motivated, will lead to the next generation of technologists, innovators, designers, and engineers.

Using Constructivist models, students participating in the program learn concepts and principles in an authentic problem-/project-based environment. Through an integrative STEM Education process, EbD™ uses all four STEM content areas, as well as English Language Arts, to help students understand the complexities of tomorrow. The EbD™ Curriculum offers the Premier Standards-Based Curriculum Model designed to be flexible, affordable, and accountable.

Technology and Engineering in STEM Education

During the *STL* implementation, ITEA and then ITEEA in 2009, made an intentional shift to directly address, support, and deliver the "Technology and Engineering" of STEM. The 2009 Louisville conference theme launched this initiative and continued through the next decade. Many projects during this time identified ways to deliver T&E instruction within STEM as an integrative approach. The "Integrative STEM Education" approach was based on the research of Wells/Sanders (2006-2010) and grew into the operational definition used on the ITEEA website. (www.iteea.org/IntegrativeSTEMEducation.aspx).

The 2010s *(growing Interest in Technology and Engineering in STEM)*

Efforts and results from the previous decade helped bring more attention to the subjects of technology and engineering. The most exciting, from our point of view, was the development of *Next Generation Science Standards (NGSS)* involving a consortium of 26 states, the National Science Teachers Association, the American Association for the Advancement of Science, and the National Research Council. The US/UK team was pleased to be invited by the National Academy of Engineers/National Academy of Scientists (NAE/NAS) to make a presentation to its *Next Generation Science Standards (NGSS)* "working group." The invitation was due to the uniqueness of our elementary preK-6 Design, Engineering and Technology program and its STEM approach. At the same time, the US/UK Collaborative Initiative and the ITEEA/EbD™ program established formal links to enhance Integrative STEM teaching and learning.

As part of this collaboration, the US/UK Team renewed its efforts to develop new products and vetting other products for adoption within our *Family of Tools and Materials* that support DE&T teaching and learning. The results of these efforts are being shared on the ITEEA website through the EbD™ curriculum and coursework and professional development through ITEEA's STEM CTL™.

The final draft of *NGSS* was released in April 2013. From our review, the standards were indeed expanded to include Science and Engineering Practices. The seven practices overlap the steps included in our DE&T approach and also match closely with the ITEEA/EbD use of the 6E Learning byDESIGN approach www.iteea.org/6ELearningbyDeSIGN.aspx. This compatibility bodes well for the planned collaborative efforts with ITEEA/EbD to extend into the next decade. *NGSS*, along with *STL*, led to the development of *Standards for Technological and Engineering Literacy*: *The Role of Technology and Engineering in STEM Education.* (www.iteea.org/stel.aspx).

Before turning attention to the 2020s, we need to consider the previous innovative projects mounted in response to selected perceived needs of the profession. The thrusts of our future efforts will be shaped, in part, by the results, impacts, and potential of these initiatives.

A Brief introduction to Four Innovative Projects *(full details at www.iteea.org/TETMayJune2022Todd.aspx)*

Examples include *TIES Magazine*, the UPDATE Projects, and the Engineers of the Future project. The fourth builds upon these three and is called the "Family of Tools and Materials'" project. Drawing upon the experiences described in the preceding pages, it appeared that the profession needed to see different and proven approaches to the teaching of TE. Timing was important as the TE profession was considering a paradigm shift in what we taught and how we taught the subjects to students, K-12.

The First Initiative: TIES Magazine

The profession did not have an independent vehicle for sharing innovative design and technology classroom practice, especially those reaching beyond our national borders. This led to a packet of sketches and schemes of possible ideas and approaches that went on a shelf. There it rested until Patricia Hutchinson came to NYU with an interest in doctoral studies in Technology Education that would extend her considerable experience in arts and design. A graduate assistantship was available, and Pat was quick to see the promise in such an effort and agreed to accept the offer, and that's when *TIES Magazine* really got started.

The Second Initiative: Project UPDATE

This initiative drew upon what we had learned over several decades including earlier work in Ohio, Libby Hunt's T4C initiative, and what we had learned in our regular collaborative work with colleagues in the U.K. That prior work laid the foundation for the NSF proposal Project UPDATE *(Upgrading Practice through Design and Technology "Engineering" Education)*.

In enlisting participants for Project UPDATE, we were pleased at the positive reactions in our targeted states—with one state, Virginia, already engaged in elementary school technology activities. We wanted to build on that interest and help them use the Project UPDATE materials and approach as stepping-stone to the empowerment of teachers and children.

The Third Initiative: Engineers of the Future

The *Engineers of the Future* Project, funded by the NY State Department of Education, drew upon the ED&E middle school and high school materials to deliver training to 400 teachers. The EOF program introduced internationally proven, standards-based, pedagogical approaches for implementing engineering education with a focus on design as a vehicle for teaching and learning.

The Buffalo EOF Project mounted a summer program that provided participating teachers choices from seven different areas of DE&T activities that took advantage of the UK team's years of experience teaching such activities in the *Loughborough Summer School*. The success of the EOF program was evident in the response of the participants; over 90% applied the training in their own schools, and 97% indicated a keen interest in participating in any future follow-up efforts.

The Fourth Initiative: The Family of Tools and Materials to Support K-6 DE&T Practice

This initiative grew out of experiences in a variety of projects. Over the past 50 years, it became evident that some key successes and failures were linked to the hands-on resources provided for teachers and students, especially tools that were being used. There was a general lack of concern or awareness of the inadequacies of adult size tools used by elementary children. The seriousness of this matter became evident as we continued our plans and efforts to submit a K-6 oriented proposal to the National Science Foundation (NSF). We had no suitable answer to this problem but were intrigued about what the UK was doing in the lower grades-

Our **AHA!** experience came on a trip to the UK that included a visit to a residential summer school for D&T teachers. Two, five-day intensive experiences at Loughborough University came to be known as the "Loughborough Summer School," which ran from the late 1970s through the 1980s, and was deemed very successful, especially in preparing elementary teachers to deliver D&T as a required subject in the national curriculum. Unfortunately, lack of funds and other issues doomed this program, but we were fortunate to see a host of teachers engaged in D&T training while the program was in full force. and to meet outstanding D&T colleagues, many of whom played important roles in supporting our Family of Tools and Materials initiative and the "Transfer of D&T to the US." (Todd and Hutchinson, 2000) (www.iteea.org/170373.aspx).

The 2020s *(Standards for Technological and Engineering Literacy: The Role of Technology and Engineering in STEM Education (STEL))*

The immediate focus for the profession is to embrace *STEL* and demonstrate how pervasive the use of T&E is as a driving force of STEM in our lives every day. T&E is prevalent in nearly all aspects of our lives as humans are dependent upon the products, systems, and processes created to help grow food, provide shelter, communicate, work, and recreate. As the world grows more complex, it is increasingly important to understand more about T&E. People need to understand technology's impacts on their lives, on society, and on the environment, as well as how to use and develop technological products, systems, and processes to extend human capabilities.

These understandings are all important elements of T&E literacy. *STEL* provides a vision of what students should know and be able to do in order to be T&E literate as well as an up-to-date roadmap for classroom teachers, district supervisors, administrators, states, and curriculum developers to promote T&E education program development and curriculum design from Pre-K through twelfth grade (www.iteea.org/stel.aspx).

The expectations embedded in meeting *STEL* standards are both exciting and daunting. The required effort will certainly produce tension, and with Tension comes the potential for Cooperation and/or Competition—so let's revisit the term "*collaboration.*" Successes reported in this article are directly related to collaboration achieved by colleagues.

Collaboration does not rule out competition. Collaborative ventures usually increase our ability to compete. For example, every proposal that was written had to compete successfully with others. Early on, we failed regularly with a success rate of, at best, 1 in 10. By the 1980s our rate reached 1 in 5. By the 1990s, having gained some important advocates, we had more successes than failures.

But collaboration was not limited to proposal writing. With the achievements of the past few decades, there is cause for excitement as to what might be accomplished in a collaborative effort related to *STEL* and other initiatives. As we focus on teachers' and students' activities, we need to give attention to the strategy of "progression," in curriculum design and development, but also in teaching and learning. But workable "progression for all" means we must provide learning experiences for young or inexperienced students as well as for more experienced students. The phrase "low-floor high-ceiling" (LTHC) describes the key design principle that guided the development of the Logo programming language. Our interpretation of that idea is that (a) the first step into a new area of learning must be as low as possible, and (b) more experienced or engaged students should be able to go as far, or high, as they want. In implementing this idea, results are difficult to achieve, but certainly worth pursuing.

This has been a rather long but exciting journey. When I started my educational odyssey in 1962, I never thought it would go so far or take so long. However, the journey needs to continue with you young people leading the way!

What have we learned in the 75-year evolution of our profession to implement technology as a subject and a unique approach that supports Integrative STEM teaching and learning?

The short answer is ...."a lot!" However, that answer is really inadequate, so I encourage you to view the online resources that accompany this article to view some points drawn from decades of experience as well as the full-length version of this article itself (www.iteea.org/TETMayJune22Todd.aspx).

In closing, we would like to share a thought prompted by the old saying … "You can't teach an old dog new tricks!" We sincerely hope that …. *"Perhaps some old dogs can teach you a few new tricks!"*

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