

Building P-16 Engineering Collaborative from the Higher Education Perspective

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Abstract

This paper presents details on a P-16 collaborative that involves several entities – The University of Texas at Tyler College of Engineering and Computer Science and the College of Education and Psychology, seven Community Colleges, forty-two School Districts, Texas Girls Collaborative, science museums, after school intervention programs, STEM summer camps, and industrial partners. This P-16 collaborative advances the professional development opportunities of pre- and in-service teachers in the area of STEM and focuses on improving student performance in these areas through the alignment of K-12 curriculum with post-secondary best practices, fostering collaboration between P-12 and post-secondary institutions, and increasing recruitment of underserved populations. Research referenced in this paper reflects the active, collaborative involvement within The University of Texas at Tyler partnership and its effect on the improved academic achievement in P-16 STEM education.

Introduction

Many education experts, business leaders, and policymakers strongly believe that the progress and continued prosperity of the United States is dependent on a knowledge-based economy that requires a dynamic, motivated, and well-educated workforce with superior science, technology, engineering, and mathematics (STEM) skills. In the report from the Committee on Prospering in the Global Economy of the 21st Century (2005), *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, recommendations were given that policy-makers should implement in an effort to meet the nation's needs for high quality jobs and new science and technology efforts. Of these recommendations, two stand out: (1) align K-12 education with the expectations of post-secondary education and (2) reform STEM education curriculum in general. There is a need for a coherent, rigorous system which spans the gap between public education and post-secondary education to assist Americans in succeeding in endeavors of innovation. According to the authors of *The Missing Middle: Aligning education and the knowledge economy*, the growing gap between Americans with “some college” and those with only a high school education or less has resulted in an income divide in the United States that has overtaken Great Britain as the country with the greatest income differences among its citizen among the advanced economies of the world (Carnevale 2002). This is exacerbating the growing gap between the “haves” and the “have nots”.

Thomas Friedman, in the book *The World is Flat*, uses the title as a metaphor for viewing the world as a *level playing field*, one where all competitors have an equal opportunity in terms of commerce and competition. Friedman suggests that there must be a shift in education if countries, companies and individuals want to remain competitive in a global market where historical, regional and geographical divisions are becoming increasingly irrelevant (Friedman 2005). The increasing demand for scientists and engineers in the United States might not be met, if today's high school students continue to perform at levels below that of other developed nations in math and science. This is coupled with the fact that fewer students are pursuing degrees in technical fields. An aggressive pursuit of improved STEM education must take place if the United States is to maintain global economic leadership.

In 2006, the Program for International Student Assessment (PISA) assessed the “science competencies for tomorrow's world” through an assessment of 15 year olds worldwide. The results of this assessment were issued by the Organization for Economic Cooperation and Development (OECD). Based on data collected, the United States was not one of the top performing countries. The best performing countries included:

- Finland, with an average of score of 563 points, was the highest performing country on the PISA 2006 science assessment.
- Six other high-scoring countries had mean scores of 530 to 542 points: Canada, Japan and New Zealand and the non-OECD countries/economies Hong Kong-China, Chinese Taipei and Estonia.
- Thirteen other countries scored above the OECD average score of 500 points: Australia, the Netherlands, Korea, Germany, the United Kingdom, the Czech Republic, Switzerland,

Austria, Belgium, Ireland and the non-OECD countries/economies Liechtenstein, Slovenia, Macao-China.

- The United States achieved a mean score of 489 points in science, on a scale that had an OECD average of 500 points and for which two thirds of the OECD student population perform between 400 and 600 points.

Among OECD countries:

- Italy, Portugal, Greece, Turkey and Mexico had lower mean scores than the United States.
- Sweden, Hungary, Ireland, Belgium, Austria, Switzerland, the Czech Republic, the United Kingdom, Germany, Korea, the Netherlands, Australia, New Zealand, Japan, Canada and Finland, as well as students in the combined area of the European Union, have higher mean scores than the United States.

According to the Third International Math and Science Study, significant improvements in Math and Science were made between 1995 and 2003. Still, American students were outperformed by seven of thirteen other countries in math, and five of the thirteen other countries in science. Teenagers in the United States lag behind most developed countries in math and science literacy (Schmidt 2005).

The Trends in International Mathematics and Science Study (TIMSS) provides data on the achievement of fourth and eighth grade students in mathematics and science worldwide. The 2007 study found that fourth graders in the United States performed as well in mathematics and science as their peers in other countries. As the students ascend through the educational system in the United States, their performance falters to the point where twelfth grade students scored the lowest in mathematics and science than any other students in the nation. This trend has been attributed to poor quality teaching as well as a weak, disconnected curriculum (Schmidt 1999).

The literature abounds with recommendations for how to foster successful P-16 programs. There is some variance among recommendations, though the core recommendations are common throughout the literature. Many of these recommendations are being adopted in a formalized way in an increasing number of states (Achieve 2008).

Some of these recommendations include:

- Align public education standards with post-secondary standards and integrate college readiness skills within the public education curriculum
- Create and maintain longitudinal data systems which track students through public education and into college or career and include this data in accountability systems
- Foster robust and continuing collaboration between public education, higher education and the business community
- Increase awareness of college requirements for students, parents and teachers especially for traditionally underserved populations

- Implement pre-college experiences which will aid in the transition from high school to college, such as; senior capstone projects, dual credit courses, early college high schools and summer bridge projects.
- Improve preparation of pre-service and in-service teachers

Four major recommendations to improve academic achievement in P-16 education are addressed in this paper. Improved academic achievement in P-16 education can be accomplished by (1) aligning education K-12 education with the expectations of post-secondary education, (2) fostering collaborations between P-12 and post-secondary institutions, (3) increasing the recruitment of underserved populations, and (4) improving teaching through pre-service and in-service professional development in best practices.

Align K-12 Education with the Expectations of Post-Secondary Education

In the SREB report *Getting Students Ready for College and Careers*, the authors assert that, “Research from ACT Inc. suggests that perhaps as many as four in five college freshmen are not ready for college in all of the key subjects. How can this be? Quite simply, states do not have college- and career-readiness standards built into high school curricula, instruction and statewide assessments.” (Kaye 2006)

In Texas, the percentage of first-time students enrolled in remedial courses in community and technical colleges — where 82 percent of publicly supported remedial course work is taught — *increased* by four percentage points between 1999 and 2002. In addition, according to ACT research, we now know that many more students than just those who take remedial courses are not ready for college. .” The SREB contends that, “If high percentages of students need remedial courses in college, it usually means that high school course content is not sufficiently aligned to college-readiness standards. It could mean that colleges are not speaking with a unified voice about what it takes for students to be ready for college. It could also mean that high school courses are not as rigorous or as focused on key standards as they should be to prepare students for college.”(Kaye 2006)

Simply graduating from high school does not ensure that a student is ready to engage in credit bearing college coursework. In other words, many students believe that graduation from high school means they are college ready, when clearly this is not the case.

Improve Teaching through Pre-Service and In-Service Professional Development in Best Practices Including Inquiry Based and Alignment with College Readiness Standards

There is a need to increase the number of STEM teachers. There is a projected need for over 2 million new teachers in this decade, of which 240,000 will be middle and high school mathematics and science specialists. A sizeable number of mathematics and science teachers do not have a major or minor in the field in which they teach, especially those who teach in high-poverty and high-minority schools. Rural schools also have a difficult time in finding highly qualified teachers with sufficient STEM backgrounds to teach in multiple disciplines.

Before It Is Too Late offered three action strategies to improve teacher preparation in STEM: “(1) identify *exemplary models of teacher preparation* whose success can be widely replicated; (2) find ways to *attract additional qualified candidates into teaching* from among high school and college students, recent college graduates, and people at mid-career; and (3) create competitively selected *Mathematics and Science Teaching Academies* to annually train Academy Fellows, who will be nationally recruited for a one-year, intensive course on effective teaching methods in mathematics or science”. Four action strategies were also outlined in *Before It Is Too Late* to retain teachers: “(1) require focus *induction* programs to help acclimate beginning mathematics and science teachers to the profession, create formal mentoring relationships, and introduce teachers to Inquiry Groups; (2) provide support for a broad range of efforts that can help create professional working environments for teachers through *district/business partnerships* to enhance teaching by providing materials, facilities, equipment, and mentor stipends; (3) provide *incentives* -- whether in the form of cash awards, salary increases, support for further education, or community-wide recognition -- to encourage deserving mathematics and science teachers to remain in teaching and improve their skills; and (4) make *salaries* of all teachers more competitive, but especially for mathematics and science teachers, whose combined preparation and skills command high wages in the private sector.”

Toward the goal of improving pre-service and in-service teacher training, teachers should be trained in inquiry based learning and be provided with inquiry based experiences. These types of teaching methods have been shown to be more aligned with college expectations. In addition, these methods are more like the methods used in Finland which has been shown to not only exceed other countries in the last three PISA studies, but has also shown a corollary effect in the successful transition from high school to college.

Institutes of higher education are seen as *the* strategic partner in building an effective P-16 alignment and collaboration for several reasons; their dual local and global nature, their ability to attract resources, their role in training teachers, their role in research and the public perception of post-secondary institutions as leaders (Hechinger Institute 2002). In spite of their importance in this system, policy-makers and institutes of higher learning have not sent clear messages to parents, students and teachers about what college readiness really means (Kaye 2006).

Pro-active measures at collaboration must occur. Robust dialogue as well as genuine integration of the standards across the span of alignment must occur for a system possessing structural integrity to be built (Martineau 2007).

Implementation of Recommendations in the Literature

The P-16 collaborative, led by the East Texas STEM Center, has worked to implement many of the actions recommended in the national and state policy papers. A short description of the intervention strategies, the preliminary results of these interventions and the current status of these interventions follow.

Align P-12 Curriculum with Post-secondary Best Practices

In the STEM disciplines, the state's intended curriculum (Texas Essential Knowledge and Skills – TEKS), the state's assessed curriculum (Texas Assessment of Knowledge and Skills – TAKS), the actually enacted curriculum as self-reported by teachers and the College Readiness Standards (CRS) as defined by the Texas Higher Education Coordinating Board have been coded by two teams of content/pedagogy experts using the Surveys of Enacted Curriculum (SEC). The SEC is a DOE-MSP approved tool developed by the Council of Chief State School Officers in collaboration with the Wisconsin Center for Education Research. The coding protocol and research regarding the tool can be found at www.seconline.org. Additionally, there are plans to analyze course syllabi for mirror courses at community colleges and four year institutes of higher education for their alignment with high school courses and the published college readiness standards.

The results of the SEC analyses are used in a variety of ways to foster P-16 alignment:

- To inform P-12 educators about the CRS, the gaps between state mandated high school coursework standards (TEKS) and assessments (TAKS) and the CRS. This serves as a non-judgmental, quantitative tool to facilitate conversation about how they might embed and implement CRS into the high school curriculum.
- To educate higher education faculty and administrators about the constraints and expectations imposed upon P-12 agencies and how institutes of higher education can use their resources to aid in the P-12 mission, thereby improving the quality of their college enrollees.
- To edify business partners of the mission of both local education agencies and institutes of higher education and how the “soft skills” these business entities require in their applicants are addressed in the P-12, community college and university environments.

Foster Collaboration between P-12 and Post-secondary Institutions

Collaboration between the partners has been facilitated through frequent communication and a multi-pronged approach. While the collaboration has been led by the East Texas STEM Center, no one entity is set forth as the ultimate authority. The collaboration is about meeting the needs of all partners, listening to input of all partners and seeing how each partners needs and resources can be leveraged for the greater good of each entity and ultimately for the greater good of the students of Texas.

Collaboration between P-12, Post-secondary institutes and business has been fostered in a variety of ways:

- P-16 Summits are held annually with public education administrators, counselors and faculty, higher education faculty and administrators, business partners, informal education providers and participants from professional associations. Open discussion regarding the needs of resources of each entity as well as the overarching goals of the collective are encouraged. Action items are identified and partnerships between subsets of the collaborative whole are also encouraged. One feature which differentiates this

collaboration from many others is the full participation by a broad representation of The University of Texas at Tyler, including the College of Engineering and Computer Science, the College of Education and Psychology, the College of Arts and Sciences, the College of Business and Technology.

- Active collaboration is promoted between various partners. This may take the form of materials support for informal STEM education providers or P-12 agencies, providing facilities for meetings or trainings, internships, professional development opportunities, curriculum development, program evaluation or providing speakers. Partners have also been encouraged to submit grants together and have been provided with support in the grant writing process.
- Participation in several local P-16 councils as well as Texas Workforce Commission local agencies has proved to be helpful in forging active relationships with community colleges and business partners in order to more effectively bring them into the conversation that is limited in some collaborations to conversations between local public education agencies and university level institutes of higher education.

Increase Recruitment of Underserved Populations

An additional directive for the reform of P-16 systems has been the recruitment and retention of underserved populations. The gap in transition between public education and higher education completion has been particularly pronounced in historically underserved populations. The creation and nurturing of active collaboration in service to the amelioration of this deficit has been addressed in several ways:

- Involvement in the National Girls Collaborative Project and the Texas Girls Collaborative Project through the American Association of University Women liaison program has served to broaden the network of partners and allows for a wider dissemination of best practices, collaboration and synergistic planning. This NSF funded project is actively involved in the creation of connections between any girl-serving, STEM-focused program most commonly including: institutes of higher education, public education agencies, business and informal education providers. Support for and involvement with this project has been beneficial for all participants.
- The collaborative has also employed the AWE (Assessing Women and Men in Engineering) tools to assess recruitment and retention of female and minority STEM students across the grade bands and in informal activities.
- The P-16 collaboration has recently partnered with a new local AVID program at a nearby school district. Advancement Via Individual Determination – AVID, is a national program which works with high school students of average academic history, often first generation college-goers who have self-selected to undertake more rigorous coursework in preparation for post-secondary participation. These endeavors have included support in training and materials and AVID students' opportunities for interaction and dialogue with current college students, college faculty and college administration.
- The University of Texas at Tyler Gear Up program is an additional partner with the P-16 collaborative. Gear Up (Gaining Early Awareness and Readiness for Undergraduate

Programs is a national program designed to increase the number of low-income students who are prepared to enter and succeed in post-secondary education. GEAR UP provides six-year grants to states and partnerships to provide services at high-poverty middle and high schools.

Improve Teaching through Pre-service and In-service Professional Development in Best Practices including College Readiness, Increase Awareness of College Readiness Standards and Increase Awareness of College Navigation

A critical component of the collaborative's efforts have been the education of participants for the big picture with regards to state efforts, national efforts and international efforts in education reform and college readiness preparation. This is most often accomplished in professional development activities with pre-service and in-service P-12 instructors. While these soldiers on the front lines may have content knowledge and pedagogical skills, they are often lacking in knowledge about how their strategies and results compare with best practices across the state, across the country and internationally. Sharing the results and implications of various indicators, as well as strategies of higher achieving programs can be useful in increasing awareness of and promoting the urgency of classroom by classroom, teacher by teacher reform. Among the quantitative results shared with all P-16 partners and most specifically dissected with P-12 partners are:

- The Surveys of Enacted Curriculum results are shared. Documents used include the SEC analyses of the: TAKS, TEKS, teacher enacted curriculum, and CRS in Algebra I, Algebra II, Geometry, Pre-calculus, Biology, Chemistry and Physics. This is followed by discussion in content groups, within departments and across content groups. With no exceptions, this has lead teacher workgroups to call for: increased training in content mapping, more opportunities to collaborate with their higher education counterparts and more time for collaborative planning.
- The results of the NAEP, the TIMMS and the PISA studies are also shared to give the participants a feel for how their students' achievement compares with other populations. The released assessment documents are also dissected and discussed within the groups. Discussion generally centers on types of assessment and current situational deficits. This discussion, without exception, has lead to the request from teacher groups for more training in: metacognitive strategies, the use multiple representations, inquiry-based strategies and the implementation of technology. In the case of middle school and elementary teacher participant groups, there is also a call for more training in the content area.

Brief Overview of Results

The collaborative efforts of this partnership have resulted in:

- Over ten grants written and awarded to various combinations of participants. This represents a leveraging of approximately 1 million into over 5 million for partnered programs.

- The uncovering of environments inhospitable to underserved populations and the subsequent undertaking of reform efforts in several key departments at the secondary and post-secondary level
- The strengthening of communication and commitment between local P-12 programs, community colleges and institutes of higher education have spawned the formation of new programs and encouraged the leveraging of resources.
- The efforts to increase the knowledge of career and college readiness needs have resulted in greater interaction among participants and improvement in college going knowledge especially among first generation college goers.

Partnerships and/or initiatives resulting from, evaluated by or enhanced by the ETxSC/University of Texas at Tyler P-16 collaboration

- GLOBE
- NOVA - NASA Opportunities for Visionary Academics
- Earth System Science Education Alliance
- NSTA – SciPak Texas Initiative
- Texas Regional Collaborative for Science
- Texas Regional Collaborative for Mathematics
- TEXESS Revolution
- Advanced Placement Summer Institute
- Texas RISE
- Texas Project Lead the Way
- Gear-Up
- Project SEED
- East Texas State Fair Academic Rodeo
- East Texas State Fair Engineering Design Challenge
- Expanding Your Horizons - AAUW
- Texas Instruments Nspire Curriculum Writing Multi-state Team
- Northeast Texas Girl Scouts STEM Initiative
- CREATE – Pre-service teacher IT
- STEM Academies' LAWTE participation
- SHELLS - Science Teacher Education for Hispanic English Language Learners in the Southeast
- Keeping America Competitive: Consortium for STEM Preparation for Engineering

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