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North Texas-STEM Center: An Engineer's Perspective

Abstract

Can engineering professors really help high school teachers? We think YES – college freshman are little different than high school seniors in terms of academic and social development. The experiences from National Science Foundation funded engineering coalitions, as well as other engineering education projects over the past couple decades, can certainly apply to math and science education at the high school level. Moreover, the projects used in first year engineering courses can be used to bring "reality" to the interdisciplinary project-based learning initiatives in secondary education. Faculty, both high school and college, can work together:

- to design learning experiences for students;
- to explore alternative teaching pedagogies;
- to explore strategies for motivating students (& teachers): and
- to find ways to connect learning for the students.

The benefits are by no means one-way from the university into the high-school. Engineering programs benefit from (1) students who are better prepared academically, (2) an increased understanding by both students and teachers of what the engineering profession does, (3) techniques for motivating students unsure of "why they need…", and (4) a better understanding of where their future students are coming from.

The North Texas-STEM (Science, Technology, Engineering and Math) center is a partnership of our university and a Dallas Independent School District (DISD) that establishes a center for STEM education that will research, create, and provide information on best practices for innovative teaching and learning. Our strategy is to create campus design teams, bringing together school administrators, teachers, students, STEM professors, STEM business partners, community-based informal STEM institutions such as museums and existing science networks in order to provide opportunity for interaction between all of these stakeholders. The products of those interactions will include: development of curriculum, implementation of that curriculum, examination of those curricula for effectiveness and distribution of those best practices across the region and the state. Campuses include math/science academies and low performing urban schools. Our goal is to work in these "laboratory school" design teams to find effective solutions. Our belief is: solutions that are effective in these schools (ranging from academies to low-performing schools) will impact STEM education in Texas schools and across the nation.

Background

There has been increasing concern over the possibility that lack of preparation will reduce the ability of the United States to compete in a world where the international economic playing field is now "more level" than it has ever been[1]. The Texas High School Project (THSP)[2] was created address this need by boosting graduation rates and increasing the number of Texas high school students prepared for college, work, and citizenship. The THSP focuses its efforts on high-need schools and districts statewide, with an emphasis on urban areas and the Texas-Mexico border. Public and private organizations in the THSP include the Texas Education Agency, the

Governor's Office, the Texas Legislature, the Bill & Melinda Gates Foundation, the Michael & Susan Dell Foundation, Communities Foundation of Texas and National Instruments.

One of the initiatives of the THSP is the development of Texas-Science, Technology, Engineering and Math (T-STEM) programs. This initiative builds on state and local efforts to improve achievement in math and science, as well as increasing the number of students entering STEM careers[2]. Funding has been awarded to establish T-STEM Centers at 5 geographically different locations. These centers will train not only the T-STEM academy teachers but any teacher and administrator in the state of Texas on how to integrate rigor into the classroom and still address the Texas Essential Knowledge and Skills (TEKS) mandated by the TEA curriculum. The North Texas-STEM (Science, Technology, Engineering and Math) center is a partnership of Texas A&M University and Dallas Independent School District (DISD) that establishes a center for STEM education that will research, create, and provide information on best practices for innovative teaching and learning.

NT-STEM center

The *focus* of the center is to work directly on inner city schools. These schools are in a highly urban location, and their student population is composed primarily of at-risk students, from low income and minority backgrounds. The *specific goals and objectives* of the center include: (1) raising achievement levels in Math and Science, (2) enhancing critical thinking skills, and (3) raising internal expectations of academic success for both students and teachers.

The *approach* chosen for the center was to incorporate project based learning as a tool to achieve goals through making learning relevant and exciting! In implementing rigorous teaching and learning requires a balanced approach to teaching, where teachers must strike a balance between lower levels of learning (such as the identification of facts) and higher levels of learning where deeper understanding of the subject knowledge is required. Engineering projects naturally incorporate a real-world context for STEM concepts to be applied, as mathematics and science are tools utilized by engineers. When those projects allow for open-ended approaches and solutions, they require students to think creatively integrate their knowledge from a variety of classes.

Each high school working with the center has a *design team* composed of professor of education, a STEM professor, and graduate students. All or the education faculty and most of the graduate students in the teams have years of high school teaching experience. The composition of these teams allows for perceived credibility, STEM content expertise, pedagogical knowledge, and models cross-disciplinary collaboration.

High Schools

We are presently working with three large, diverse, persistently low performing high schools and one new, small, STEM high school academy in the Dallas Independent School District. The difficulties faced on a daily basis by the staff in these high schools, particularly the large ones, are frequently daunting and often depressing. One school has had three principals within a period of 1½ years. All three of the large schools have had at least two principals during that

time, and we did not know who any of the principals for this school year were going to be until early August, right before school started. One school has been completely reconstituted because of three years of failing to meet Annual Yearly Progress (AYP) on No Child Left Behind (NCLB). The instability of teachers, administrators, students, and student families in these schools can serve to undermine many efforts [3-6]. Many of the high schools that serve these students are so persistently low performing that low academic performance becomes embedded in the school's culture [7-9]. Our challenge is to change the culture within the school to one where success is perceived as achievable by all (i.e., effort based intelligence).

Teachers

Often the least successful and/or least experienced teachers in a district teach in these schools. Many of the teachers are alternatively certified and have little experience in any successful teaching environment. As a result many of the teachers, particularly the teachers who care the most, are overwhelmed with students' personal problems to such an extent that focusing successfully on academics becomes difficult[10-11].

Due to all of the challenges and problems described above, the teachers are focused on how to improve test scores. Teachers have low expectations for their students – they don't expect most of their students to attend college, and are focusing on just getting them to complete their high school degree. The hard work of teachers and center design teams is slowly building a Learning Community that crosses departmental boundaries – all are excited about the possibilities and see the potential for better learning in small groups and with PBL. Remaining to be solved are:

- not sure how to overcome logistical problems
- how to work within a constrained syllabus,
- communication barriers across departments (lack of common meeting time, etc.)
- lack of experience with active learning strategies,
- where/how to get needed materials and support.

Students

The poverty, the low educational attainment of parents and thus little access to decent jobs, among other causes, create almost impossible conditions for these students' families.[12-15] Right now the main motivation for students (like teachers) is to pass the test – reinforced by explicit statement of TEKS/TAKS objectives on board. They don't see any connection between what they do in the math classes, their science classes, or with the real world. Some instructors do try to make ties but they do not have domain expertise, and can run into problem of varying nomenclature, etc., thus obscuring the connections.

There is hope: in one lab – students were observed to be engaged and excited about the experience. Teacher had posed problem within real life context (cop catching speeding car – motion down incline surfaces)

Remaining challenges include:

- Don't know how to work in groups on written assignments
- Don't know anyone who has gone to college – not part of their expectations for themselves and other classmates. They don't know anyone who is an engineer – they don't see that as a possible career path, much less connect College as a way to achieve future career goals.

What do we do? – A Typical Professional Development (PD)

A "typical" sequence of professional development (PD) is used to move teachers from a focus on "passing the test" to a focus on "achieving learning outcomes." The sequence includes:

- Introduce Professional Learning Communities (PLCs) to build connections between and among teachers. This can be particularly critical in creating connections between teachers in different departments – for example, connecting the math and science teachers.
- Introduce Active Collaborative/Cooperative Learning (ACL) to build student engagement in classroom ACTIVITY
- Introduce Project Based Learning (PBL) to build connections between core subject areas – no project is solely focused on learning in math (or science, or English or social studies) – and to build student ownership of the learning objectives
- Introduce Engineering as the context for "real-world" projects to build student buy-in (why do I need this? → I need this to get a good job/contribute to society, etc)

There are several challenges to be overcome during a PD. The major ones are typically rooted in teacher's mental models of their classes and students. Typical statements the teachers will make include:

- "I don't have time to cover all of my TAKS objectives & do a project" → We need for the teachers to realize that the TAKS objectives for all core subjects overlap & many of the objectives can be accomplished in the context of a real-world project (not "covered")
- "I don't know enough content outside of my class to do a project" → We need to instill a mentality that "together we can"
- "The students will go wild" or "Once I let them become active in class I will never regain "control" → This issue can be addressed by Classroom Management Techniques & Team Development Training

While all of these issues need to be addressed; the professional development can be customized for an individual campus (or group of teachers) by packaging them in a "just in time" fashion. This provides an opportunity to model many of the active collaborative/cooperative learning (ACL) strategies as well as Classroom Management techniques.

How to Evaluate Program Impact

No single performance metric is capable of assessing the impact of intervention strategy. In part this is true because we are talking about cultures and people, beliefs, as well as academic performance – leading to both quantitative and qualitative metrics. Another complicating factor

in performance assessment is the length of time between our intervention and their success. It will be 4 or 8 or more years before the students we affect today graduate from high school or college or achieve success in their career. Some indicators that can be used at different time frames are listed below:

Short-term:

- Energy level in the classrooms
- Greater student engagement
- Conversations in the professional learning communities (PLCs)
- Increased number of students graduating from high-school

Mid-term:

- Improvement in teacher performance indices
- Increased number of students attending 4-year university

Long-term

- Student test scores
- School ratings (i.e.- exemplary)
- Student's successful completion of a 4-year university engineering program

Summary

Progress has been slow. These diverse urban high school environments are difficult; **to give up on these students is totally unacceptable**. Urban high school students are too large of a group and too large of a percentage of all high school students to give up on. Due to the size by number and percentage of this group, it is an economic necessity for these students to be academically successful if we are going to continue to have a thriving economy. We need students who can model their success for other urban students in order for us to be successful. Visible success leads to changing attitudes and expectations at all levels – from students, to teachers, to school administrators, to school boards and to the community.

Bibliography

1. National Academy of Sciences, *Rising Above the Gathering Storm*. PDF, www.nap.edu/catalog/11463.html
2. Texas Education Agency, "Secondary Initiatives: Texas High School Project," http://www.tea.state.tx.us/ed_init/sec/thsp/, accessed January 18, 2008.
3. Firestone, W. A. & Rosenblum, S. (1988). "Building commitment in urban high schools." *Educational Evaluation and Policy Analysis*, 10(4), pp. 285-299.
4. Rumberger, R. W. (1983). "Dropping out of high school: The influence of race, sex and family background." *American Educational Research Journal*, 20(2), pp. 199-220.
5. Rumberger, R. W. & Larson, K. A. (1998). "Student mobility and the increased risk of high school dropout." *American Journal of Education*, 107, pp. 1-35
6. Weiner, L. (1999). *Urban teaching: the essentials*. New York: Teachers College Press.
7. Erickson, F. (1987). "Transformation and school success: The politics and culture of educational achievement." *Anthropology and Education Quarterly*, 18(4), pp. 335-356.
8. Fine, M. (1991). *Framing dropouts: Notes on the politics of an urban public high school*. Albany, NY: State University of New York Press.

9. McPartland, J., Balfanz, R., Jordan, W. & Legters, N. (1998). "Improving climate and achievement in a troubled urban high school through the talent development model." *Journal of Education for Students Placed at Risk*, 3(4), 337-361.
10. Lankford, H., Loeb, S., & Wyckoff, J. (2002). "Teacher sorting and the plight of urban schools: A descriptive analysis." *Educational Evaluation and Policy Analysis*, 24(1), pp. 37-62.
11. Raudenbush, S. W., Rowan, B., & Cheong, Y. F. (1992). "Contextual effects on the self-perceived efficacy of high school teachers." *Sociology of Education*, 65(2), pp. 150-167.
12. Haveman, R., Wolfe, B., & Spaulding, J. (1991). Childhood events and circumstances influencing high school completion. Demography, 28(1), 133-157.
13. Jencks, C. & Peterson, P. E. (1991). The urban underclass. Washington, D.C.: The Brookings Institution.
14. Noddings, N. (1992). The challenge to care in schools: An alternative approach to education. New York, Teachers College Press.
15. Steinberg, L., Brown, B. B., Dornbusch, S. M. (1997). Beyond the classroom: Why school reform has failed and what parents need to do. New York: Touchstone Books.