ENGINEERING INSIGHTS: DEVELOPING STEM EDUCATION FOR STUDENTS WITH DISABILITIES LEADS TO K-16 PARTNERSHIPS

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Abstract - RASEM², a National Science Foundation (NSF) sponsored project in New Mexico and west Texas, addresses the unequal representation of students with disabilities in science, technology, engineering, and math disciplines. Therefore, the authors committed to an understanding of pre-college public education which led to the establishment of K-16 initiatives including bridging programs, summer camps, teacher outreach, professional development, mentorships, and research. In addition, the New Mexico Department of Education and Commission on Higher Education together formed a K-16 Partnership group to study and recommend effective strategies fostering quality teaching and learning in all levels of education. The primary author was selected as member of this group. Particularly interesting was the fostering of relationships between college and pre-college educators and the integration of methodologies pursuant to the K-16 Partnership objectives. Most important involvement in the Partnership fostered a K-12 outreach with the charge to better understand pre-college education.

INTRODUCTION

Colleges of engineering do not usually associate themselves with public school education or understand the mechanisms driving pre-college education except, of course, when actively recruiting students. It is critical that we go beyond this mind-set and build a strong working relationship with the teachers, school administrators, and those entities that provide vital services to the public schools. If we rely on others to make sure that current and future generations of students are ready to enter college with a strong grasp of math and science fundamentals, then we are only kidding ourselves.

Going back some two decades, the NSF noted that the traditional home market of scientists, mathematicians, and engineers was steadily shrinking [1]. If the United States were to continue leading the world in technical innovation and thought, where would our future scientists, mathematicians, and engineers come from? The conclusion was obvious, you either import from abroad and/or you tap into those groups not typically well represented in the science, technology, engineering, and math (STEM) arena. Thus, NSF made a concerted effort to sponsor projects that would address the imbalance. The projects focused on two aspects, upgrade the math and science skills of underrepresented groups, and encourage more and more of these individuals to seek STEM career paths.

Yet in this process the realization came late to NSF that students with disabilities were potentially a very fruitful source for scientists, mathematicians, and engineers. It has only been in the last roughly 10 years that NSF has dedicated resources targeted specifically toward students with disabilities. The NSF has established a number of major initiatives geared to have a systemic impact on math and science education, and the Regional Alliance for Science, Engineering, and Mathematics for Students with Disabilities Squared, or RASEM², is among them. Engineering colleges must make an investment in initiatives such as RASEM², helping out whenever we can to assure that they are successful.

The RASEM² experience emphasized that those involved in our public schools are eager to gain the technical expertise represented in engineering colleges. They are also eager to share their knowledge. RASEM² became a player in the math and science scene through selected projects with common objectives uniting pre-college and college educators. As RASEM² learned so did the college of engineering. Other engineering colleges can also become players if they take the initiative to make the contacts, seek out common ground, and take the plunge.

THE REGIONAL ALLIANCE

For many reasons not detailed here, students with disabilities in the public schools have been directed away from pursuing a math and science education track. Refrains are often heard along the lines that math and science, and ultimately, engineering are too taxing or difficult for students facing “special educational challenges”. Throughout educational history students with disabilities were pigeonholed into believing this falsehood. Not surprisingly, statistics show that representation in STEM disciplines by persons with disabilities is less than half that of the population as a whole.

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Technology know-how to their students with disabilities. SpEd teachers with computer technology. When these computers, the point of the workshops was to familiarize the Internet, learn basic software, gain training with adaptive applications were the normal topic. A mini-workshop would have SpEd teachers get experiences on the local schools to recruit. The mini-workshops were limited to a half day to a day typically on a Saturday. The numbers were kept to a manageable level (no more than 10/workshop) to a half a day to a day typically on a Saturday. The numbers were kept to a manageable level (no more than 10/workshop) and computer applications were the normal topic. A mini-workshop would have SpEd teachers get experiences on the Internet, learn basic software, gain training with adaptive devices, and, generally, made to feel comfortable with computers. The point of the workshops was to familiarize SpEd teachers with computer technology. When these teachers return to the classroom, they then bring the technology know-how to their students with disabilities.

RASEM² found these early contacts to be both enthusiastic and hesitant at the same time. The contacts realized that our mission was to their liking, but you could sense the questions “who are these guys?” and perhaps more importantly “are we there with a purpose and commitment?” It was tentative, to be sure, but at least it was an opening.

Our commitment was there and we truly wanted to build a strong and lasting relationship that would benefit all and to this end we rapidly established a number of joint ventures. RASEM needed to reach out and touch students with disabilities in the public schools and how better to do this than through teachers. The result was the Teacher Outreach Projects (TOP) with small cash awards ($1,500 or less) going to teachers and their schools. TOP let the creativity of special education and/or math and science general-education teachers craft hands-on math and science activities for their students. Although students with disabilities were the target audience, RASEM encouraged teachers to be inclusive to make sure that students with disabilities were accepted as part of the whole. RASEM relied on our contacts to get the word out, and they did.

Most of the TOP projects were targeted at middle schools in the belief that students have not selected a career path at this point in their lives. Further, biases have not yet been planted in their minds about particular disciplines and the opportunity was there to positively influence their feelings about high tech careers.

RASEM was pleased to discover that a number of these projects have continued beyond the funding cycle, thus multiplying the impact beyond that originally envisioned. The success of TOP was phenomenal and the trust multiplied. For example, TOP touched the lives of 1,605 middle and high school students with disabilities which represents 39% of all students who have participated in the program. In addition, some students with disabilities who have participated in the TOP program have also enrolled in the RASEM Summer Science Camp (RASSI) and 10.34% of those RASSI participants have enrolled in college. It is noteworthy that according to the NSF, less than 6% of persons with disabilities are currently in STEM careers. Obviously TOP and RASSI have had a significantly positive effect on those students with disabilities who participated. Since the projects are inclusive, we can only surmise that the effects were also positive for their nondisabled peers.

Among the two-hundred SpEd, science/math, and general education teachers who have coordinated TOP projects, the most significant and useful activities have always been those that break stereotypical approaches to teaching science and/or math to students with disabilities. The simplest include partnering students with disabilities with nondisabled peers, allowing students with disabilities to suggest their own solutions to classroom physical access, and not assuming that all disabilities, even from the same
categories, require the same teaching approach, i.e., taking a case-by-case approach to teaching students with disabilities. Other successful strategies available for use by teachers in their classrooms were the use of college students as mentors helping with hands-on activities, parents to help supervise project activities, and teachers learning how to use assistive devices. This is one area in which teachers have needed extra help. As a result, workshops have been developed to expose teachers to different types and uses of assistive devices, such as software that allows blind students to use the computer; Smart boards that can be used to record digitally what the teacher is writing on the board so that notes can be downloaded later; techniques on how to present to students who are deaf or have hearing impairments, and how to work with the interpreters in the classroom.

Ultimately teachers inexperienced in teaching students with disabilities were helped to realize that their expectations about students with disabilities, ideas which may have been heavily influenced by the prevailing negative and burdensome attitudes about disability, were totally untenable and baseless. As a result, their confidence grew, they were more willing to apply a case-by-case approach to teaching which often resulted in simple solutions to teaching math and science to students with disabilities, and many were excited about creating future TOP projects. This new awareness applied to the students as well, i.e., disabled peers became less of someone to be avoided because of their differences and more acceptable because of their skills and talents.

When one talked about math and science in the same breath with students with disabilities, RASEM realized that there was a lack of communication and cooperation between special education and general education math and science teachers. How can these groups work together to make a difference? With this as a premise, RASEM and Region 19 ESC sponsored teacher development workshops to bring each group together to explore methodologies on how to engage students with disabilities when teaching math and science. For RASEM, it was another layer of trust leading to well-received workshops at several of our partner colleges.

In the long run, RASEM sponsored many collaborative efforts with the public schools. Most prominent beyond TOP was a mentorship program through which college students with disabilities mentored middle and high school students or mentees. Once again teachers were our best source for identifying mentees.

Through this mentorship program, mentors were required to maintain regular contacts with their mentees. Naturally their method of choice was through the Internet because it was the easiest, quickest, and most accessible. To solidify the mentoring concept, however, RASEM conducted math and science camps to bring mentors and mentees together face-to-face. Further, RASEM would pose math and science problems or questions and then challenge the mentor/mentee teams to work together in solving the problem or answering the question. The first team to get it right was awarded a prize along the lines of a book or poster. It is interesting to note that a number of the mentees are now at college age and a significant number of these are choosing to enter college under a STEM discipline with the greatest percent in engineering.

RASEM used these contacts to establish an “in” with the public schools. They got to know us and we got to know them. However, as we went along the realization dawned that much more was happening in the public schools of which we needed to be aware. The RASEM director and associate director sought answers to what was going on.

**The K-12 Experience**

The RASEM directors began looking at the dynamics unfolding in the public schools with regard to math and science education. Foremost, K-12 education was directed to establish standards-based math and science education. Foremost, K-12 education was directed to establish standards-based math and science by actions taken at the executive and legislative branches of government. Accountability became the dominant concept with students now being required to pass standards-based math and science competency exams to verify their abilities. Both teachers and teacher aids are being pushed toward certification. And, the public schools are struggling to put all of this into place.

From the perspective of special education, the K12 educational structure is governed by the Individuals with Disabilities Education Act (IDEA) and not the Americans with Disabilities Act (ADA), a civil rights focused law that covers higher education. For students with disabilities, IDEA is a great step forward but it has a serious drawback for students that may be very capable in math and science. In a quick sentence, IDEA states that students with disabilities must graduate with the abilities to be a workforce productive citizen. Its drawback is that it invariably leads to an educational system that provides the minimum resources to make this occur. For students who may have higher aspirations or capabilities requiring greater resources, the system is not really set up to help them achieve at this level.

RASEM also found out that students with disabilities with STEM potential were not being effectively transitioned into college. Because higher education is governed by ADA, it is up to the students to be self advocates in promoting their own success. Universities will not seek them out and automatically provide them with the services they need. Students with disabilities must plan ahead to adjust to the differences between IDEA and ADA. Public schools use Individual Education Plans (IEP) to chart their students’ educational paths. It is during the formulation of the IEP that a university can potentially influence the outcome, including an effective transition, provided that access is built in. It is
not a closed process with the student, parents, and teachers dictating who is to participate. RASEM looked upon the process as an opportunity to have higher education make a difference in students’ lives while they were still pre-college. However, making the difference would require resources, expertise, and influence beyond the scope of the RASEM program.

In the ensuing search for solutions, the RASEM directors saw the dramatic changes taking place in the public schools and wanted to know what mechanisms were shaping the process. Could we invest ourselves into the process? It did not take long to realize that it was again NSF leading the way. NSF was quick to note that math and science test scores in American public schools were trailing behind scores from students in other industrialized countries [7]. Something was wrong and to correct it would require directed resources. In response, NSF formed systemic initiatives, the relatively new math and science partnerships, and other collaborations to promote systemic changes in math and science pedagogy in our public schools. NSF was saying that the teaching of math and science needed to be standards-based and respond to the needs of all constituencies. Teacher professional development, hands-on learning, involving the parents, and engaging school administrators are some of the strategies employed by the initiatives to make this happen.

Because RASEM wanted to be a player in the changes taking place and saw an opportunity to improve dramatically the educational experience of students with disabilities, especially in science and math, we early on forged a partnership with the Comprehensive Regional Center for Minorities [8] (CRCM) located in the northern part of New Mexico. NSF was the sponsor of the CRCM, a program intended to increase minority participation in math and science. Shortly after the CRCM/RASEM link was established, however, NSF abolished the CRCM program by in effect switching it to a rural systemic initiative. The initiative, called UCAN [9] for Utah, Colorado, Arizona, and New Mexico, was given the charge of promoting systemic changes in math and science pedagogy in the four corners region of the country. The switch from CRCM to UCAN became the authors’ first true introduction to the concept of the systemic initiatives.

This introduction lead to an attempt by the directors to collaborate with the NMSU College of Education, a number of school districts in proximity to the Mexican border, and two southern New Mexico Regional Cooperatives [10] to create a rural systemic initiative for the southern half of the state. The Cooperatives, spread throughout New Mexico, were created to provide special education services to the public schools. Their mission has since broadened to include services of all types.

Although unsuccessful in creating an initiative, the process was tremendously enlightening to the authors who learned of the existence of a whole network of math and science education specialists charged with making a significant impact on math and science pedagogy. Specific programs with which RASEM has developed ties are the Texas Rural Systemic Initiative [11] (TRSI), the Southwest Education Development Laboratory [12] (SEDL), the Navajo Nation Rural Systemic Initiative [13], the Northern New Mexico Rural Systemic Initiative [14]. UCAN completed its funding cycle and was basically segmented into several initiatives serving the associated states and nations.

An interesting collaboration with SEDL came recently at the NMSU College of Engineering professional development seminar hosted by the College and the New Mexico Space Grant Consortium [15]. SEDL’s Dr. Steve Marble, a contact provided by RASEM, was invited to be a keynote speaker and a facilitator of faculty discussions on effective teaching. He brought a perspective of public school teaching methodologies to higher education and sparked a lively and healthy debate among the faculty. The experience was widely applauded by the faculty that participated and will surely produce an ever-widening cross-fertilization with public school educators toward the betterment of all concerned.

It was clear from the RASEM efforts that RASEM needed to foster even greater contacts with the initiatives and others to make a difference in math and science pedagogy in New Mexico and west Texas. NSF recognized the viability of cooperation between its various initiatives and now require Memorandums of Understanding between them. The directors of RASEM believe that this is a formality that should be happening anyway. Similarly, Colleges of Engineering do not have to wait for an NSF initiative to come their way to initiate cooperative ventures with those initiatives in their region of the country.

**GETTING INVOLVED**

Once the authors committed to an understanding of pre-college public education, the path led inexorably to involvement in the K-12 network. The New Mexico Department of Education and Commission on Higher Education banded together to form a K-16 Partnership group to study and recommend effective strategies to foster quality teaching and learning throughout all levels of education. Of particular interest was the fostering of relationships between college and pre-college educators and the integration of methodologies pursuant to the K-16 Partnership objectives. The principal author joined in the Partnership becoming the only representative from a college of engineering. This was a good decision. Being a member meant providing critical input, particularly in the teaching of math and science, in a series of meetings held in the state to draft a working document. It also meant getting to meet and know many
prominent public educators throughout New Mexico, a win situation from a college of engineering perspective.

Involvement in the K-16 Partnership lead to an invitation to participate in the Southern NM Regional Roundtable to promote quality teacher preparation and professional development. Again it seems like an odd fit for an engineering professor, but the opportunity to influence the path of teacher professional development toward a greater emphasis on math and science makes it worthwhile. Obviously, the payoff for this involvement is long term. Change takes time. But, without the impetus for change, it will never happen.

Through another opportunity brought about by RASEM\(^2\), the NMSU College of Engineering agreed to take the lead in the southern portion of the state in a math/science partnership (MSP) initiative submitted for funding to NSF. The MSP is a joint effort between the colleges of education and engineering that will permit the engineering college to have a fundamental impact on the K-12 math and science education for years to come. The MSP proposal is under review but as of this moment funding has not been announced. If funded, professors within the college will work with teachers in developing hands-on curriculum that emphasizes engineering content. Also, the two participating colleges will work together to assure that effective math and science teaching methodologies and professional development will be commonplace in the regional schools.

**CONCLUSION**

It can be argued that RASEM provided a unique opportunity to the NMSU College of Engineering that is not available to other universities. This is true up to a point. What RASEM really did was to let the College know that the centers and initiatives were out there. Armed with this knowledge it was then contingent on the College to exploit the opportunity with a call to the directors. Colleges of engineering do not need to have a RASEM in order to initiate these contacts, however. Based on experience, the directors are often eager to develop new collaborations toward the benefit of both parties. With this said, though, one needs to approach the directors carefully with a strategy for working together. What will not fly is an attempt to simply use the centers or initiatives as a recruitment platform. The goal of the colleges of engineering, for example, should be to enhance the math and science pedagogical skills of SpEd teachers and general education teachers. If this is accomplished, then over the long run recruitment will take care of itself.

Another lesson learned is that cooperative ventures do not always have to involve money. Initiative directors, for example, would likely welcome volunteer faculty and college students willing to assist with the development of hands-on science demonstrations or the opportunity to bring students or teachers to campus for a math/science learning experience. Often engineering computer laboratories are under utilized on the weekends. Why not conduct half-day Saturday workshops for teachers using these laboratories? The good feeling engendered in teachers that participate carries over to the public schools. As previously mentioned, RASEM conducted such mini-workshops to upgrade the technical skills of special education teachers allowing them to more readily assist general education math and science teachers when a student with a disability is in their class. We asked students to help out as a public service project under the supervision of a professional staff person. The cost was minimal.

These initial contacts need follow-through. Based on experience, the directors are going to look for evidence of commitment particularly over the long haul before they enter into a collaborative relationship. In effect, they do not want to be left holding the bag should the colleges back out. Do they want money? Yes and no! Of course they would not turn down an opportunity to conduct professional development seminars, for example, paid for in part with the assistance of university funds. Equally likely, however, the public schools and the various NSF initiatives would appreciate other types of support such as in-kind, use of facilities, etc.

The authors strongly encourage each and every college of engineering to reach out to the public schools and public school administrative structure. Use systemic initiatives, the regional service centers, and public school educators as a way into the network. The rewards for this effort will pay off. Give them a call and let the adventure begin.
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