ENGINEERING AND ELEMENTARY SCHOOL PARTNERSHIPS
(or DEAN KAMEN’S CHALLENGE REVISITED)

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Abstract - What can engineering students and faculty offer to inner city fifth and sixth graders and their teachers – and vice versa, what could be the benefit to engineering departments? In this paper we will describe a successful partnership that is now in its third year. The elementary students are from an inner city neighborhood where the high school dropout rate is high – about 30%. Using the projects that have been developed as a context, we will describe the history of the partnership, the benefits to all parties involved, and some of the surprises that were encountered. We will also address how this partnership seems to be another answer to the challenge presented to engineering educators by Dean Kamen at the 2001 ASEE Conference in Albuquerque, New Mexico. That challenge was - and still is - to draw promising students from educationally disadvantaged backgrounds into engineering and technically based careers.

Index Terms – community service, engineering and inner city school partnerships, ABET 2000 Criteria, professionalism, under-represented groups in engineering

INTRODUCTION, INVITATION, AND CHALLENGE

This paper is a description of a partnership between an engineering school and an inner city elementary school. Our purpose in describing this partnership is to offer it as an invitation and a challenge to other engineering schools to try a similar partnership. We draw engineering students into the partnership by presenting it as a responsible citizenship issue. There is a need: inner-city schools are under-funded and resource-poor. As a result many children are not prepared to compete in a technology-driven world and we lose a valuable resource. In a free society, the solution is the responsibility of the citizens. As citizens we can meet this need in a unique way that also builds professionalism for our students.

Over three years the project described in this paper has involved 2 lead engineering faculty members and more than 80 engineering students in community-based service learning. At the same time it has involved three fifth grade teachers and over 200 fifth grade students as well as two 6th grade teachers and more than 80 6th grade students. A major component of the partnership (described in detail later in the paper) is the Pinewood Derby Project in which each 5th grade child builds and races a pinewood derby car using the kit available from the Boy Scouts of America. The costs in terms of time and money are minimal in comparison to the impact on the children and the engineering students. The total cost for 76-80 children – including prizes for the race – was under $600 each year. The entire project was completed in a 2-week period with many opportunities for busy engineering students to be involved for as little as an hour of total time invested… and still gain an important experience.

In his plenary address to the 2001 ASEE Conference, inventor Dean Kamen challenged engineering faculty members to become involved in FIRST (For Interest in Robotics, Science, and Technology). FIRST is the high school competition that he founded in order to retain talented students at the high school level and encourage them to pursue advanced studies in technical areas. In this paper we describe another approach to this challenge. Our interaction is at an earlier age, it is more local (FIRST is a national event), it can potentially involve more students, and it is less costly. By mentoring the engineering students in this project the faculty have also been able to satisfy the ABET 2000 Criteria that call for placing engineering activity into social context and for increasing student awareness of ethically based responsible citizenship in a free nation. If every engineering school would find just one local inner city or struggling school and try a similar partnership, the impact on elementary education would be enormous and it could potentially include thousands of talented children who currently leave school at the first opportunity. This is a lost resource that hurts all of us.

A SHORT HISTORY

The partnership between the Padnos School of Engineering (PSE) and the Sibley Elementary School fifth grade started in the fall of 2000 with a call to the principal and an offer to work with the teachers and children in one grade. Sibley is about 7 blocks from the downtown campus of Grand Valley State University. It serves a neighborhood marked by poverty. One of the authors of this paper had previously worked with children from the neighborhood who attended this school. This experience and the documented 30% high school drop out rate for the neighborhood were the factors that motivated the initial call to the principal. He did not hesitate to suggest fifth grade because the children were about to enter a much larger regional middle school/junior high where individual attention for the students would be less likely. This was (and still is) a concern for the staff at

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Sibley because most of the children have very little support for academics at home and they have few role models for scholarly success. Their role models are quite the opposite in most cases. The staff was looking for a way to motivate these children to stay in school once they enter the larger school because almost everything else in their lives motivates them to drop out – and education is the primary path out of the poverty in which they are growing up.

In the first meeting with the fifth grade teachers we had no idea what a partnership meant or what we could do. We simply started a dialog that has proved to be extremely beneficial to all of us.

**WHAT HAPPENED?**

Our first activity was to provide bicycles, safety helmets, and bicycle locks for 26 of the children who did not own a bicycle and whose parents could not afford one. This was part of an on-going program called Bikes for Kids, a service project in which engineering students refurbish bicycles that have been donated to the project. The only problem with this activity was that it did not involve all of the children. We next looked for another activity that would involve all of the fifth graders and provide increased interaction with engineering students – who could become role models for the children in the process. In consultation with the 5th grade teachers, we decided to have each child build a pinewood derby car with assistance from engineering students. Kits were available at the local Boy Scouts of America supply store for less than $4.00 each.

While children in more affluent neighborhoods often build a pinewood derby car in Cub Scouts (or a similar club that enjoys significant adult volunteer help), the children in very poor neighborhoods often do not have the same opportunity because they do not have similar clubs. In fact, very few of the children at Sibley had ever seen a project like this one and they clearly appreciated the opportunity to make a car. The project also coincided beautifully with the science lessons on simple machines that the classes started on just after Christmas.

We first came to each of the classes and showed the kits and examples of completed cars to the children. We then talked with them about how engineers use drawings to design products such as cars and gave them a worksheet with a full-size top and side view of the wood block from which the car would be cut. Each child was able to sketch the top and side view (including hidden lines!) of the car that they planned to make. The worksheet also included a space for choice of color so that we would know which spray enamel colors to purchase. From the thank you letters that the children wrote it was clear that the opportunity to make the car “exactly how I want it” was very important to these children. Their sense of mastery and control was a joy to see.

After introducing the project and before the children started building the cars we planned a visit to the engineering lab building. For the past two years we have moved this visit to the early fall so that our interactions with them will occur at regular intervals over an entire school year. For the visit, engineering students served as guides and the classes were rotated through three separate activities spanning about 2 hours. This tour served three purposes: it provided an opportunity for the engineering students and the fifth graders to meet each other, it allowed the fifth graders to become familiar with the engineering labs so that when they returned to race the cars they would feel “at home” in our labs, and it opened their eyes to the possibility that coming to college is something that is within their grasp. For many children this was the first time that they seriously considered the possibility that they could enter this world and their new friends – the engineering students – were critically important to helping them to see this. The children were excited and the teachers were delighted to overhear fifth graders talking about college as a possibility for the first time! This identity with the “new engineering friends” deepened once they started building the cars with the help of these new friends. For the more thoughtful engineering students, this first interaction was the first time that they realized that from the point of view of poverty, college might appear to be an impossible dream.

**DETAILS OF THE PINEWOOD DERBY PROJECT**

**Preparation**

Engineering students and faculty used the worksheets completed by the children to pre-cut the kits using band saws in our shops. For the past 2 years the students in our pre-engineering classes completed the pre-cutting. Many of the pre-engineering students are also members of under-represented groups in engineering and we found that the opportunity to represent the profession of engineering in this type of a project was very appealing and motivating for them. We included drilling a hole for adding molten lead (something that we did) to increase the weight of each car to regulation weight. Pre-cutting greatly reduced the time needed for sanding and shaping. As a result, each class of 20-30 5th grade students was able to completely sand the cars in one 40-minute session. When the engineering students cut the blocks they put each completed pre-cut block, the remainder of the kit (box, wheels, and axles), and the child’s worksheet drawing into a one-gallon zip-lock plastic bag and put the child’s name and the teachers name on the bag. Throughout the week of building the car, 5th grade students returned the car to this bag each time that they finished working on it. Such organizational details were extremely important to assure that each child would be able to complete his/her car in the three days of the building phase without losing parts.
Building the cars

We spent three days at the school and each day we spent one hour with each class. Engineering students signed up to provide shifts of 4-6 students at any given time and at least one engineering faculty member assisted at all times. On the first day when we saddled the cars we found that it was helpful to bring a small electric disk and belt sander to take care of major modifications. Eye protection was important for this and the children were quite excited to be able to put on safety glasses and to learn how to operate the sander. (Check with school policy on the use of tools. It may be necessary for engineering students to use the machines while children watch and direct.) It was also important to bring dust masks for the children with severe allergies – something more common in the inner city schools.

This was the first opportunity for engineering students to work closely with the children on a one-to-one basis and it was wonderful to see children beginning to identify with the engineering students. The students have done a wonderful job of guiding the children to do their own work. We spent some time with the engineering students explaining how important it is for the child to see this as a personal accomplishment…and our engineering students have not let us down. Many engineering students remember making pinewood derby cars themselves and it is not unusual to overhear them sharing their own experiences with this same project. This is another place where the fifth graders begin to identify with the engineering students.

On day two we spray-painted the cars in the same timeframe as day one: three one-hour long sessions. We had a large selection of colors (gold, silver, and red have been in high demand) and allowed each child to pick one. Because of the fumes we did end up doing this outside. We made spray-painting booths out of large cardboard boxes and lined the bottom liberally with newspaper. Most of the children had not spray-painted before so we gave each one a short lesson and allowed them to do their own painting. Once the cars were dry they were put back into the plastic bags.

On day three we helped the children add the wheels and encouraged them to try using a hammer. To further individualize the cars we supplied the children with a variety of water-based acrylic (model) paints and brushes. This was a very important step for the children; here the creativity was unleashed and it was not unusual for the original color to be entirely changed.

Once assembled and dry, the cars were put back into the plastic bags and taken to the engineering labs where engineering students and faculty added the weights. For the race, organization is again the key to making this a good experience. Participation ribbons are filled out before the race and the cars – along with the ribbons – are laid out on tables by class. When the children are ready to race each child finds his/her car on the table and stands next to it until it is time for him/her to place the car on the racetrack. Each class takes a turn racing while the other two classes watch.

Simple times determine the first, second, third, and fourth place winners and medals are available at the Boy Scout supply store. In addition to the places we award pins and patches for “happiest paint job”, “most yellow”, “most patriotic”, etc. and each child receives a participation ribbon. While prizes are important to these children, we realized last year that the children did not focus on the prizes. For them, the opportunity to make the car with the help of the engineering students was the prize…and they all had this prize plus the best reminder possible: they each had their car.

Observations

A sense of mastery and achievement are always important but they are especially important to these children. Most of our students come to us with a wealth of such experiences and they expect to be able to design, build, and understand the components of their world. Lacking such experiences in their formative years, what would enable these children to build the same essential expectation?

The interaction with engineering students is a significant part of this experience. It was not unusual to overhear fifth graders ask engineering students questions such as, “Did you ever get a C?” It is much easier for them to identify with the engineering students than professors – who are more like their teachers. The bond of shared experience is also important to building an identity with the engineering students. Interaction is also important to engineering students who represent their profession to the children and thereby build their own sense of identity as engineers.

Coming to the labs for a tour before the race gave the fifth graders a sense of ownership in the building and allowed them to concentrate on the race. For the past two years we have been able to add to the excitement of race-day by having a real racecar and driver in the lab building and giving the children a chance to sit in the driver’s seat.

Including the tour and the race, the project involved five periods of interaction – each one 2-3 hours long. At least one engineering faculty member was present at all times but students could staff these periods in shifts of about an hour at a time. This provided an opportunity for meaningful service without overwhelming very busy engineering students. The cost in time and money is small compared to the benefit to a large group of children.

We gained some appreciation of the positive effect we had last year when we returned this year. Sixth graders recognized us, remembered our names, and asked if we were doing cars this year…and if so, which grade? This year’s fifth graders had watched last year and had eagerly anticipated their turn. When we started the fall semester with another short engineering exercise (blasting off water rockets and measuring altitude vs. driving pressure), they enjoyed the rockets but asked us when they would begin the car project. In a remarkably short time a culture has developed here in which the children anticipate this
interaction. This anticipation may well make this even more effective as a “bridge builder” for these children.

**OTHER DEVELOPMENTS**

In the first year, after the race the children wanted one last interaction before the end of the school year. We planned one last visit to the engineering labs in late May. This was just before the end of their school year and near the beginning of our summer term. This involved a new group of engineering students. Again, there were 3 activities culminating in a picnic. One of the activities was an impromptu design activity involving teams of engineering students and fifth graders. We held the competition during lunch and the prize was simply knowing that the winning team won. It was clear once again that for these children the prize is the opportunity to have this experience.

**Can you please do something for 6th grade?**

This was the question that we began to hear at the first interaction in the fall. Last year the 6th graders who had raced cars in the previous school year asked if we could also do something with them. In fact, for the past two years they have asked if they could build cars again since they now have some really good ideas! (We explained that they had discovered the design process!) What we did was to add another interaction at the beginning of our summer semester in parallel with the fifth grade picnic. On a separate day the sixth graders came for three different activities culminating in a picnic and including an impromptu design. To prepare for the visit the sixth graders built simple water rockets and they were asked to name a particular robot in our lab and write a short adventure story about the robot. When they came for the picnic we announced the winning name, read the best stories, and included an exercise in which the sixth graders operated the robot. This year we will repeat the morning visit with activities and the picnic for both the fifth and sixth grades.

**Is There Any Other Way for Us to Help?**

During the first year of the partnership - after the race and in conversation with the fifth grade teachers we found that they needed help in introducing simple electric circuits. They had no equipment, almost no budget, and little experience in this area. They were also so overwhelmed with other problems that they skipped this part of the science curriculum. This placed their students at a disadvantage in state testing and for future academic work, but they did not know how to approach these lessons. This was easy for us to do with equipment commonly available in engineering labs. Three faculty members designed a simple exercise and delivered it in each classroom. The teachers observed and commented that they could handle this themselves from now on. Last year, our electrical engineering students built simple training boards for series and parallel circuits. We worked on a short written worksheet to accompany the training boards and we delivered the electricity lesson again. Each classroom now has 4 training boards and the teachers have gained confidence in adding this to the science curriculum.

In a similar way conversations with the sixth grade teachers have led to plans to build simple spectrosopes using plans available from IEEE. This will assist in teaching the science unit on light and once again, engineering students will help us build 4 spectrosopes for the school. The engineering students will also help the faculty design a simple exercise using the materials available from IEEE. This will enhance their ability to communicate effectively with different audiences.

This year we also worked with a third grade teacher on helping each third grader build a small wooden box using a hammer and nails. This was a project that the teacher had done for many years but found difficult to complete in a timely manner. We were able to complete the boxes in just one session with engineering student help and we were able to add a short exercise on tracing the parts and measuring them using tape measures that we were able to supply for the children to keep.

The important thing to note in each of these projects is that we would never have been able to answer these needs if the dialog between engineering faculty and elementary school teachers had not been established. The ideas keep coming as we know the teachers better and as we become a part of the culture of the school. In every case there are benefits for all parties involved.

**BENEFITS**

There are many benefits for all groups involved in this partnership. For the fifth graders (who remain as the primary focus group) there is a larger sense of their own potential as they are able to identify with engineering students who they see as friends. This experience has increased their expressed motivation to stay in school and it has certainly increased their sense of mastery of the world around them. The fifth grade teachers have gained a potentially powerful ally for science, mathematics, and technology instruction. Certainly the open dialog provides a wonderful resource. This much answers the challenge articulated by Dean Kamen – and that alone might be a good enough reason to undertake a project such as this one, but there are also clear benefits to engineering faculty and students.

First, there is the sense of satisfaction, fulfillment, and pride that almost always accompanies effective service work. Because the projects are clearly related to engineering, they allow both students and faculty to build a stronger professional identity. A significant number of students initially planned to help out for only an hour and ended up staying all three hours and coming back another
day. Clearly this work answers some need; just as the experience is the prize for the fifth graders, the experience of helping a child reach a greater level of achievement is its own reward. On a deeper level, studies have shown that service learning can provide a meaningful context for higher education [1].

The experience itself is a direct consequence of the interaction of engineering with a local community; we are helping the children of our own local community to understand what we do and to see a potential place in our profession. The new ABET criteria requires faculty to develop a curriculum that enhances responsible citizenship, and increases awareness of social impact and the effects of engineering activity on the larger community. It is sometimes hard to find opportunities in a standard curriculum to discuss what it means to be an engineer and a responsible citizen of a self-governed nation. Pre-college education is an issue of major importance to our nation – especially in the information age. In a self-governed nation this is not a problem for the government to solve, it is a problem for citizens to solve. In our case, the university borders a neighborhood where more than 30% of the children who start high school drop out. As educated professionals and as citizens we cannot afford to ignore this problem. It is our problem too. For that reason we present this project to our students as a citizenship issue and we clearly present our reasons for doing it. Our reason for doing this is to help these children (who are our neighbors) be competitive in an information-based and technology intensive economy. We are not doing this because we feel sorry for them and as a result our projects always involve children learning and doing things for themselves with our assistance. To provide further context for our reasons we share with our students the words of the 31st President of the United States (and engineer), President Hoover: “Our individualism differs from all other because it embraces these great ideals: that while we build our society upon the attainment of the individual, we shall safeguard to every individual an equality of opportunity to take that position in the community to which his intelligence, character, ability and ambition entitle him; that we keep the social solution free from the frozen strata of classes; that we shall stimulate efforts of each individual to achievement; that through an enlarging sense of responsibility and understanding we shall assist him to this attainment; while he in turn must stand up to the emery wheel of competition.” [2] President Hoover linked these ideas to liberty in the U.S. in the following way: “It (liberty) demands freedom from frozen barriers of class, and equal opportunities for every boy and girl to win that place in the community to which their abilities and character entitle them.” [3] These ideas provide a rich context for our own discussions with our students as we complete this project together.

We, as most engineering schools, find that most of our student body shares a very similar life experience. As engineering students begin to know the children raised so differently from their own experience, they begin to appreciate an approach to life very different from their own approach. As they struggle to “walk in someone else’s shoes” they grow in understanding. Faculty who carefully mentor a project such as this one can greatly enhance this understanding. Such understanding is enhanced by periods of reflection – something that is sometimes difficult with engineering students. In “Projects that Matter – Concepts and Models for Service Learning in Engineering”, a number of essays related to service learning in engineering are presented. One of the essays, “Service Learning Reflection for Engineers: a Faculty Guide”[4] discusses the importance of reflection and also some of the difficulties encountered when this is attempted with engineering students who are often not comfortable discussing “feelings”. The reflection phase has been especially difficult for us because this project is not a part of a class. Participation is entirely voluntary and extra-curricular. For us, the thank you letters that the children write provide an opportunity for reflection and deeper understanding of the tremendous potential for good that we are privileged to carry. We set up an ice-cream sundaes party or some similar event during which the letters are shared. We also send thank-you letters with the quotes from President Hoover that were given earlier in this paper. The entire engineering student body has gained some benefit from the discussions that flow out of the activities that have been completed.

**SUMMARY**

In this paper we have attempted to provide a case study with enough detail to enable others to try a similar project. The exact details of your project will probably be different because you live in a different community. Near the beginning of this paper we noted that when we first discussed this partnership with the fifth grade teachers, none of us had a clear idea of what we would do. What we did involved an element of risk because there were no guarantees, but then again, engineering is inherently exactly like this. We will adapt and learn as we go. For us, the pinewood derby project clearly works well. Last year we incorporated cutting the wood blocks into a freshman design course that requires students to master the use of machine tools. The engineering students were delighted to be doing something really useful for someone else...so we will continue to build on that in the coming years. This early experience may become an opportunity to more fully explore professional and ethical responsibility in our interactions in society. It has already led to many wonderful discussions about the special problems encountered by people in different social and economic groups. Our service projects provide a meaningful context for these discussions. The most important thing is simply to begin. We hope that our experience and our observations provide a starting point for others.
A Final Story

There are many wonderful stories related to this partnership. We will end with this story: At the end of the school year Dr. Fleischmann was leaving Sibley School when a group of about six little boys came running to the playground fence yelling “Dr. Fleischmann, Dr. Fleischmann! What is that thing on top of Keller Labs?” The “thing” was a wind turbine that was a focus for one of the senior projects. This episode was significant for several reasons. First, the boys had obviously gone past the lab on their own and had noticed something different about it. Our experience with people in this neighborhood has been that they do not enter our campus areas. The children feel welcome there and that is an important first step. Second, they have friends on the faculty and among the students at Grand Valley. Dr. Bogdan and Dr. Fleischmann are viewed almost like Sibley teachers – we are a part of their world and we love it. Third, when they asked the question they fully expected to be able to understand what the wind turbine was. This reflects a wonderful level of expectation for mastery that is so essential for any further study. Dr. Fleischmann was able to explain what the wind turbine was and what the engineering students were doing with it. The little boys ran off to share this exciting new information with other friends. We hope that we are making an early contact with future students in engineering or other technical fields.

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